

February 1993/\$3.00

# Mobile Radio Technology

The journal of mobile communications technology

Cellular telephone antennas, p. 10

Cellular system quality assurance  
Testing and repairing solar panels  
Digital SMR technology

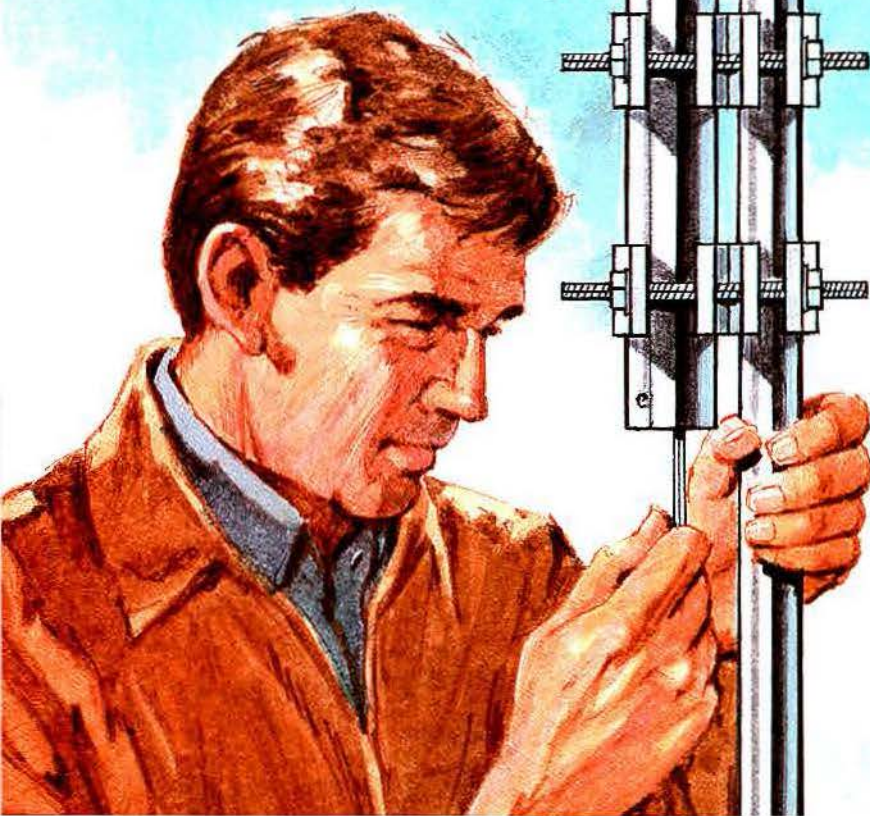
10th Anniversary Issue

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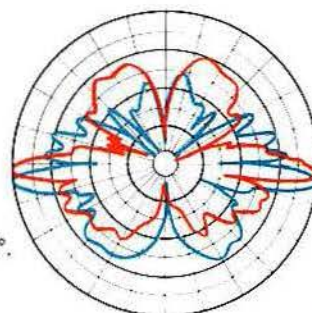
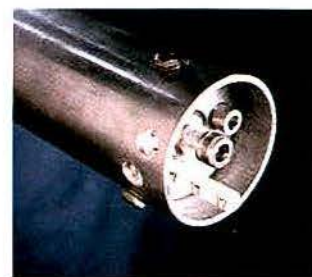
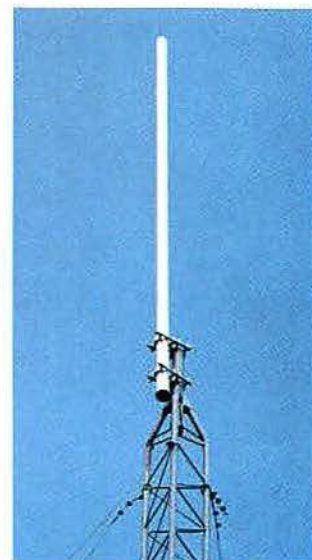




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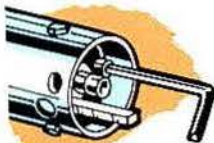
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*Roald Steen*

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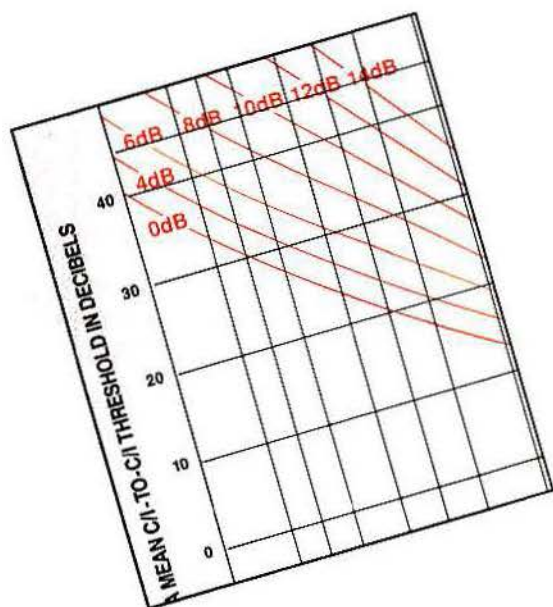
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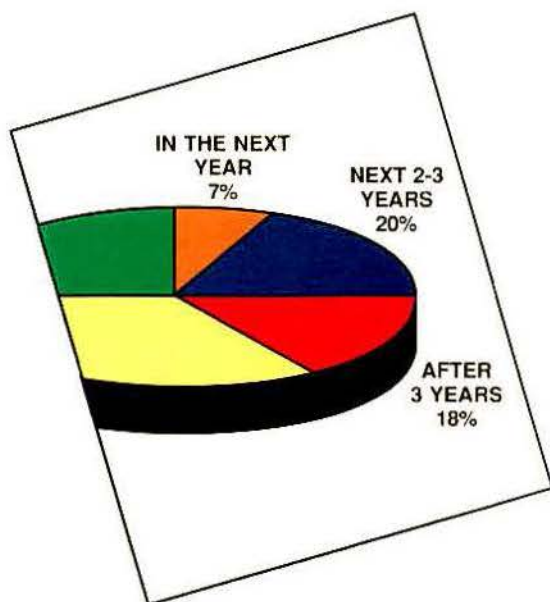
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## Scanning . . .



### Anniversary

This issue marks *MRT's* 10th anniversary.

What began as an idea among three partners who wanted to start a magazine for the mobile radio industry has grown and thrived, thanks to our readers, contributing writers, advertisers and staff.

People who have experience with many trade magazines tell us that we have the best readers anyone could want.

From a business standpoint, that means our readers renew subscriptions at many times the rate of most trade magazines, and they respond to advertisers in high proportions. From an editorial standpoint, many readers participate in the magazine's content through correspondence, telephone calls and contributed articles.

Our contributing writers supply a great deal of the information we offer. These experts range from technicians to engineers to entrepreneurs with first-hand knowledge of the skills and technology to improve radio communications systems and services that our readers build, maintain and use.

Advertisers play a dual role, providing the bulk of our revenue and supplying information about products and services that readers want to know about, through advertising and editorial contributions.

The staff brings all the elements together, including editorial, sales and

circulation, along with other support functions. Credit for our first 10 years of success goes to all of the staff who have played a part in sustaining the magazine.

Although we cannot name everyone who deserves thanks for helping us reach our 10th anniversary, I want to dedicate this issue to Jim Fahnestock, our founding editor, who was my mentor during the magazine's first 3 1/2 years. Thanks, Jim.

Thanks to everyone who has helped the magazine to grow. It has been a great 10 years, with more to come.

\* \* \*

### Refarming

As this issue goes to press, the deadline for filing comments in the FCC's spectrum refarming proceeding is about a month away.

The proceeding would replace Part 90 of the FCC's rules with a new Part 88, a step that represents a wholesale rewriting of the rules.

Spectrum refarming refers to changing the way radio frequencies are assigned and how they are used in an effort to make room for more users and to improve radio communications. It would displace some current users and would require upgrading radio equipment.

Initial reactions to the proposal are what might be expected.

Many of those who would be displaced and who would have to spend money to upgrade equipment are displeased, especially if they are satisfied with their present communications capability.

Manufacturers can see the potential for new radio equipment sales. Radio communications service providers, such as specialized mobile radio (SMR) system operators, can see the potential for constructing improved systems on the refarmed frequencies and attracting new customers.

There is a cost. There is always a cost. Radio users will have to spend

money to upgrade their systems, and that money, ultimately, will have to come from their customers or taxpayers. Will communications be improved? Will communications services be extended to new users who cannot now obtain frequencies? The argument can be made that they will. Some of the current users will argue that it will not be worth it.

The outcome of any rulemaking proceeding is uncertain. Sometimes no action is taken. That does not seem likely in the face of a 400-page proposal. There is a *lot* of push behind this one.

Whatever form the new rules may take, they will keep everyone busy for many years, from the manufacturers to the service providers to the users. And the lawyers, who will have a fresh new set of rules to interpret and tussle about as they advance their clients' interests.

That's progress. Probably.

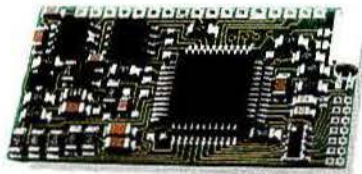
—Don Bishop



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## March

- 2-4—Cellular Telecommunications Industry Association Winter Meeting and Exposition, Dallas Convention Center, Dallas. Contact: 202-785-0081.
- 17-19—Western States Regional Conference Associated Public-Safety Communications Officers Meeting, Hyatt Regency, Phoenix. Contact: Deborah L. Overton, 602-256-1029.
- 21-24—Energy Telecommunications and Electrical Association, New Orleans Convention Center, New Orleans. Contact: 214-235-0655.
- 23-25—International Mobile Communications Expo/Spring, Anaheim Convention Center, Anaheim, CA. Contact: 303-220-0600.

## April

- 19-22—Supercomm and Telocator Wireless Conference, Georgia World Congress Center, Atlanta. Contact: 800-326-8638.
- 21-23—North Central Regional Conference Associated Public-Safety Communications Officers Meeting, Radisson Inn Bismarck, Bismarck, ND. Contact: Lyle V. Gallagher, 701-224-2127.

## May

- 12-14—Annual Mobile Communications Conference, sponsored by the National Association of Business and Educational Radio (NABER), Hyatt Regency Hotel, San Antonio. Contact: 800-759-0300.
- 16-19—East Coast Regional Conference Associated Public-Safety Communications Officers Meeting, Cavalier Hotel, Virginia Beach, VA. Contact: Bill Marriott, 804-247-8431.
- 18-20—Vehicular Technology Conference, sponsored by IEEE Vehicular Technology Society, Meadowlands Hilton, Secaucus, NJ. Contact: George D. Gaul, 908-290-1128; fax 908-290-1932.
- 26-28—RadioComm, Metro Toronto Convention Centre, Toronto. Contact: Lisa La Prairie, 613-233-4888.

## June

- 29-July 1—Utilities Telecommunications Council Annual Meeting, San Antonio Marriott Rivercenter and Convention Center, San Antonio. Contact: Rita Clark, 301-621-7802.

## July

- 18-22—Forestry-Conservation Communications Association, Jackson, WY. Contact: Don Pfohl, 602-644-3166.

## August

- 8-13—Associated Public-Safety Communications Officers 59th National Conference, New Orleans Convention Center, New Orleans. Contact: 800-824-1850.

## September

- 21-23—International Mobile Communications Expo/Fall, Philadelphia Convention Center, Philadelphia. Contact: 303-220-0600.
- 28-Oct. 1—Mobile Communications Marketplace, New Orleans Convention Center, New Orleans. Contact: Telocator, 800-326-8638.

## October

- 6-9—Industrial Telecommunications Association Annual Meeting, La Quinta Hotel, La Quinta, CA. Contact: Barbara J. Levermann, 703-528-5115.
- 12-13—SMR/Private Carrier Management Conference, Loews Coronado Hotel, San Diego, CA. Contact: 202-331-7773.
- 16-21—International Association of Chiefs of Police Annual Conference, Cervantes Convention Center, St. Louis, MO. Contact: 703-836-6767.

## November

- 19—Radio Club of America Awards Banquet, New York Athletic Club, New York. Contact: 201-652-6811.

## 1994

## February

- 7-8—AMTEX, the American Mobile Telecommunications Association's Marketing and Technology Conference and Exposition, Marriott on International Drive, Orlando. Contact: 202-331-7773.



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The journal of mobile communications technology

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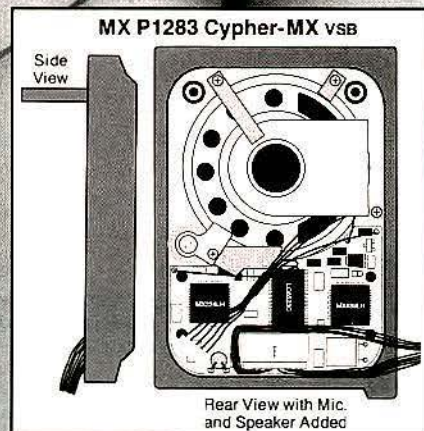
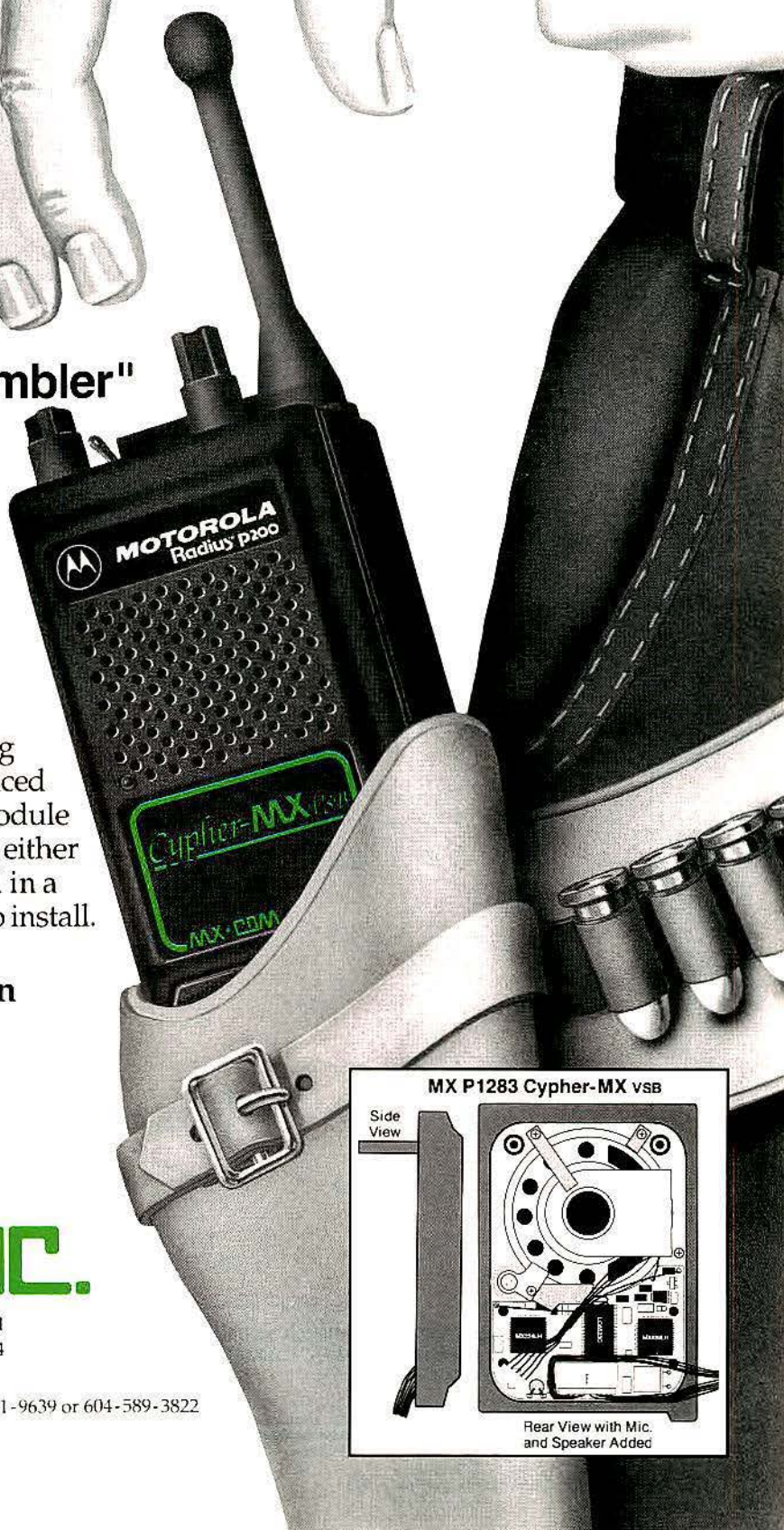
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## Designing your own pads, part 1

By Harold Kinley, CET

Attenuators and impedance-matching pads can be useful around the radio shop.

Attenuators and pads are used for RF and audio applications. Eventually, you may need to build your own attenuator for a special purpose. Here are a few basics about attenuators and pads that will help you when you build your own.

Pads are used for two basic purposes, impedance-matching and attenuation.

Unfortunately, with resistive components, you cannot design an impedance-matching network without significant attenuation. As undesirable as the loss may be, it is unavoidable with resistive networks.

Nevertheless, the attenuation often can be tolerated and *must* be taken into account when deciding whether or not a resistive pad is the best way to match impedance for a particular purpose.

### L-pads

The simplest impedance-matching pad is the L-pad shown in Figure 1 below.

Upon close examination, you will notice that this L-pad is nothing more than a simple voltage-divider network. It consists of two resistors: one *arm* resistor,  $R_A$ , and one *leg* resistor,  $R_L$ .

This pad matches a 75Ω impedance with a 50Ω impedance.

If you must design an impedance-matching resistive network with *minimum loss*, an L-pad is the proper choice. Only one set of values for  $R_A$  and  $R_L$  satisfy an impedance match in both directions.

The L-pad is said to be *asymmetrical*. This means that the impedance does not look the same from both directions. Assuming that a 75Ω source is connected to  $Z_1$  and a 50Ω load is connected to  $Z_2$ , the source sees an impedance of 75Ω.

Vice versa, when a 50Ω source is connected to  $Z_2$  and a 75Ω load to  $Z_1$  the source sees an impedance of 50Ω. Thus, the impedance match is bidirectional.

When designing an L-pad, first run the formula in Figure 1 for minimum loss. If this amount of loss is intolerable for the application, the L-pad is unsuitable.

Next, consider a matching network

using reactive components (inductors and capacitors).

These sometimes are called *lossless* matching networks, though, in practice, a certain amount of insertion loss is inevitable. The disadvantage of reactive component matching networks is that they are frequency-sensitive and more difficult to build.

If an L-pad's minimum loss is acceptable, then you can determine the arm and leg resistance values  $R_A$  and  $R_L$  from the Figure 1 formulas. In building an L-pad such as the one in Figure 1 (75Ω/50Ω), be sure to mark the two ports with the proper impedance label.

Better yet, use an F connector for the 75Ω port and a BNC or other 50Ω connector for the 50Ω port. This will help to prevent reverse-connecting the L-pad.

Figure 1's L-pad attenuation is approximately 5.7dB.

Important points to remember about the L-pad are:

- (1) It is asymmetrical—the impedance is different at each port.
- (2) It is used to provide an impedance match between two unequal impedances.
- (3) It cannot be used between two equal impedances if an impedance match is to be maintained in both directions.
- (4) It cannot be used as an attenuator to provide more or less than the loss provided by the Figure 1 formula and still provide an impedance match in both directions.
- (5) It is unbalanced.

### T-pad

Some of the L-pad's shortcomings can be overcome with a T-pad.

Figure 2A on page 49 shows a T-pad. It can be used between equal impedances to provide any degree of attenuation and still maintain an impedance match in both directions.

(continued on page 49)

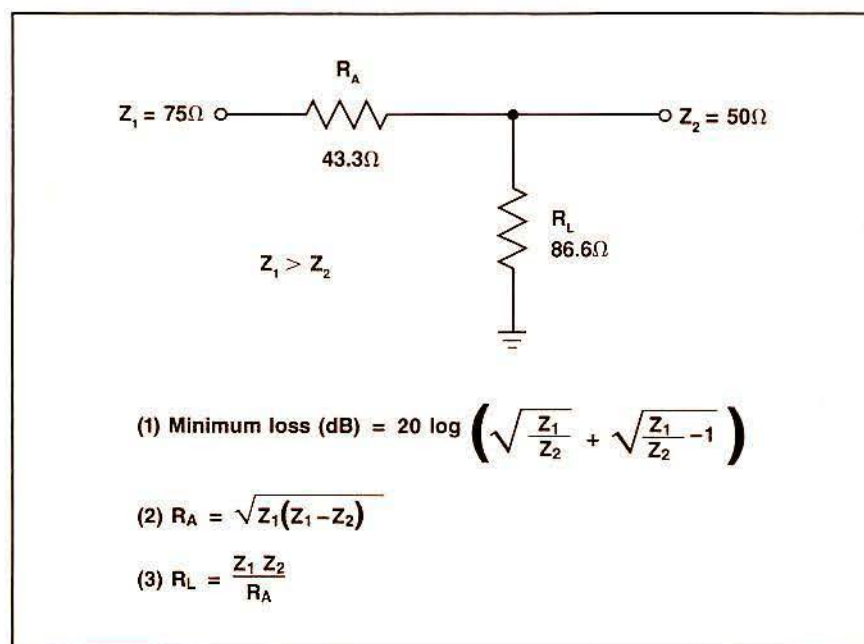


Figure 1. The simplest impedance-matching pad is the L-pad, which is nothing more than a simple voltage-divider network. It consists of two resistors: one *arm* resistor,  $R_A$ , and one *leg* resistor,  $R_L$ .

Kinley is a certified electronics technician with the South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual With Instrumentation and Testing Techniques*, Prentice-Hall, 1985.



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# Mobile, portable, base station cellular telephone antennas

*Most cellular telephone systems are engineered so that a variety of customer telephone equipment works well. Here is how to get the most out of several kinds of antennas that are popular with customers and system engineers.*

By Roald Steen

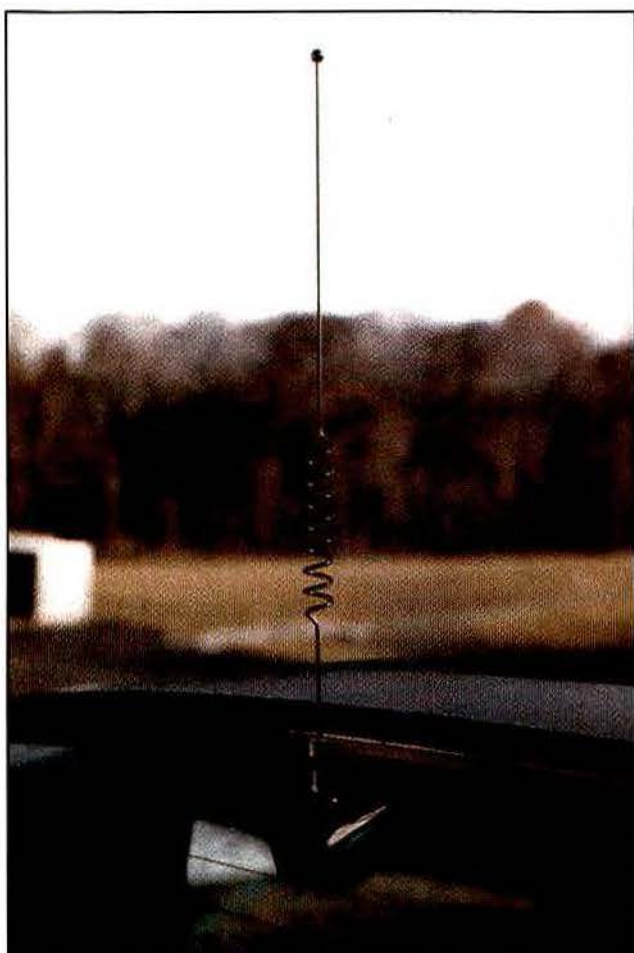
Cellular telephone antennas are available for mobile, portable and base station equipment.

At the 800MHz frequencies used for cellular communication, conductor diameter influences antenna size and design. At lower frequencies, conductor diameter is less important because it is proportionally smaller compared to the antenna length.

Generally speaking, an antenna with a large-diameter conductor is slightly shorter and has a larger bandwidth compared with an antenna with a small-diameter conductor at the same frequency.

Maximum power is transferred among components with the same impedance. With 50 $\Omega$  coaxial cable as the standard transmission line, mobile and base station cellular telephone outputs are designed for 50 $\Omega$  impedance, and so are antenna connections.

Antennas themselves sometimes have a different impedance than 50 $\Omega$ . In that case, the manufacturer includes a matching network between the con-



A glass-mount cellular antenna with 3dB gain. The best location for this antenna is near the window's upper edge.

ductor and the antenna.

The simplest cellular mobile antenna, the quarterwave whip, normally does not require a matching network.

The impedance of a quarterwave antenna over a metal ground plane is close to 50 $\Omega$ . A quarterwave whip

antenna, fed with a 50 $\Omega$  coax cable such as RG-58 or RG-8 and properly installed near the center of a metal vehicle roof, shows little reflected power when tested with an in-line wattmeter.

Due to transmission line losses, the power that reaches the antenna is lower than the power reading at the transceiver output. For the same reason, reflected power is somewhat higher at the antenna than at the transceiver coax connector.

Antennas are efficient because they radiate almost all of the radio energy delivered through a properly matched coaxial cable.

Nevertheless, there are other significant losses in the antenna system.

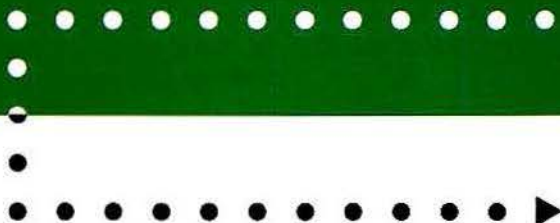
► **Cable attenuation**—A given type of coaxial cable's attenuation depends on its length and operating frequency. At cellular frequencies, attenuation is high, so it is common to lose 1dB to 2dB of the input power in the cable between a mobile antenna and the cellular transceiver.

► **Polarization loss**—A cellular telephone's antenna should be positioned vertically to match the base station antenna's positioning or *polarization*. Just as matched impedances allow maximum power transfer among components, matched polarization al-

Steen is an electronics instructor and two-way radio technician who lives in Woodbury, MN.



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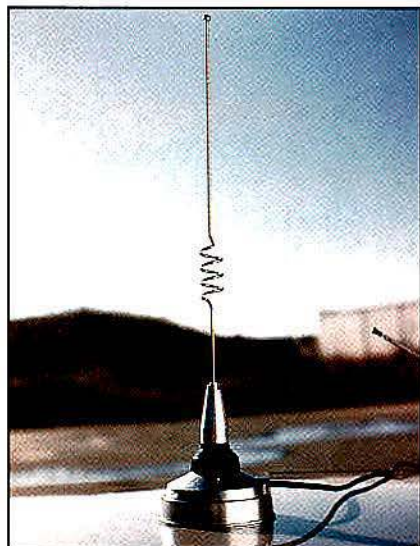
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lows maximum signal transfer among antennas. (There are exceptions involving reflected and other signals, but for most cellular communications, matched polarizations are best.)



A magnetic-mount cellular antenna with 3dB gain.

A slight tilt from the vertical does not have much adverse effect, but mounting cellular mobile antennas at rakish angles of 45° or more from the vertical should be avoided, and antennas on portable and transportable phones should be positioned as close to vertical as possible.

► **Antenna gain**—An omnidirectional vertical antenna's gain concentrates the radio energy it emits in the horizontal direction.

It usually is preferable to concentrate the power horizontally because the angle at which the radio signal travels between cellular telephones and base stations usually is within a few degrees of horizontal.

► **Downtilt**—Power emitted above the horizon from an elevated base station antenna usually is wasted. Thus, downtilt is used with some base station antennas to concentrate the radio energy at an angle a few degrees below the horizon. Most downtilt antennas focus the signal between 3° and 8° below the horizon.

Downtilt can be achieved mechanically or electrically. Mechanical downtilt means that the antenna is physically tilted. It is more commonly used with directional antennas.

Electrical downtilt means that the antenna elements are phased so the maximum radiation occurs a few degrees below the horizon. It is more commonly used with omnidirectional antennas.

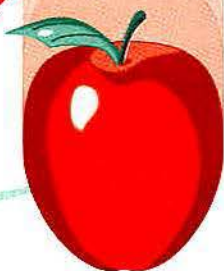
Most of an antenna's electrical characteristics apply equally to transmitting and receiving, so a good transmitting antenna is a good receiving antenna and vice versa.

► **Power rating**—Antenna specifications include a maximum power rating.

In an efficient antenna system, the antenna's power rating tends to be higher than the coaxial cable's power rating. In such a system, the coaxial cable's rating determines how much power can be transmitted.

Cellular telephone equipment uses relatively low power, so the antenna

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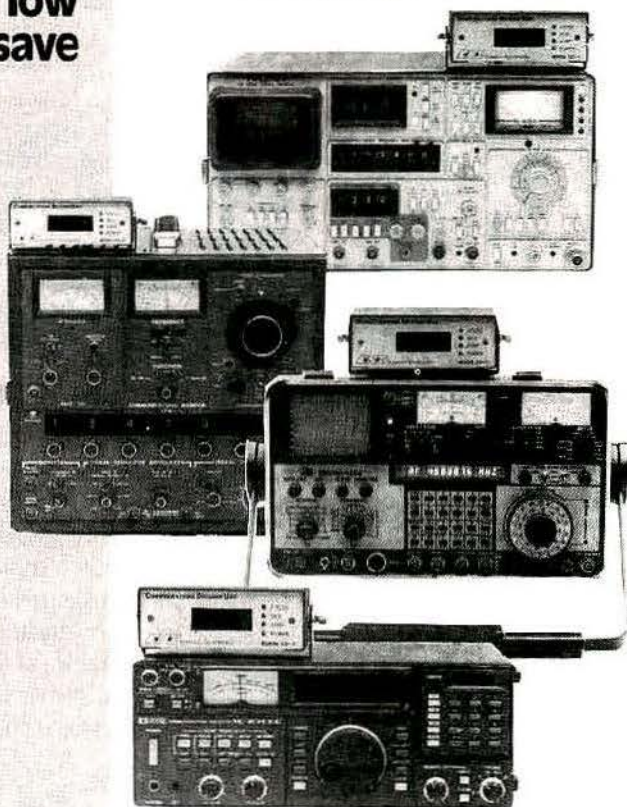
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system's maximum power rating seldom poses a problem.

Cellular antennas have a relatively broad bandwidth because the equipment operates on a wide span of channels in the 800MHz band.

Except for the vertical antenna mounted on a ground plane, such as a metal vehicle body, most antennas do not present a 50Ω load to the transmit-

ter. Therefore, they must be designed with some type of matching network. The simpler the network, the better.

#### Size vs. frequency

Because cellular telephones use a high frequency and small antennas, some conditions may cause bigger problems than they do with antennas for lower frequencies.

Ice and snow may be more likely to affect short cellular antennas than longer VHF antennas. Dirt and salt deposits may cause more problems with short cellular antennas.

Many cellular base station antennas, therefore, are enclosed in plastic or fiberglass. The protection ensures that the antenna is less likely to fail because of snow, ice, salt spray or dirt.

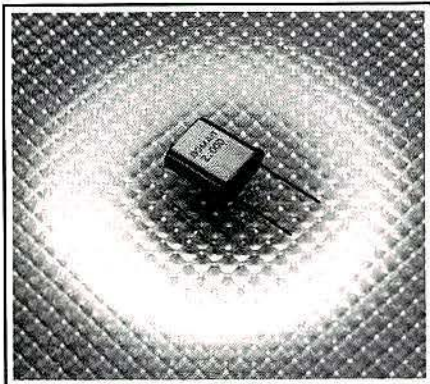
#### Weathering

An antenna is exposed to snow, rain, ice, wind, dirt, vibration and corrosion. It is important that it be designed to withstand all such problems.

A simple antenna design is less likely to fail in adverse conditions than a more complicated design. Most cellular mobile antennas are simple; they use a phasing element and a radiating element made from a single wire or metal rod.

Avoiding metal joints circumvents

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*A simple antenna design is less likely to fail in adverse conditions than a more complicated design. Most cellular mobile antennas are simple . . .*

problems that might occur because of mechanical malfunctions stemming from vibration and stress.

Corrosion may occur in the antenna base if it is not completely weather-proofed.

The ground plane is an important component of current-fed mobile antenna systems.

Current-fed antennas are designed to be mounted on the metal vehicle body, which forms the ground plane. Elevated-feed antennas use a special design that allows them to be used on a stalk that holds them above the vehicle body to clear the rooftop.

The best ground plane is flat, large



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and unobstructed. Thus, the best location for a current-fed antenna usually is the center of the roof. Antennas that depend on a ground plane work best in the directions where the ground plane is largest. Centering the antenna on the roof results in the best omnidirectional emission pattern.

Speedometer wire can be used to fish the coaxial cable through hollow spaces in the vehicle's roof support. A speedometer cable flexes and follows the spaces inside the roof supports in a manner that often simplifies the job of bringing the coaxial cable up through the roof support. A speedometer cable is an inexpensive and convenient installation tool.

Avoid putting the antenna on the trunk lid, if possible. This position places the antenna near the passengers' heads, needlessly exposing them to transmitted radio energy close to its source. Although studies indicate the health risk of such exposure normally is quite low, falling within federal guidelines, it is even better to avoid

mounting antennas on trunk lids.

Glass is an effective dielectric (insulator). Therefore, radio energy can be coupled from a coaxial cable to an antenna through window glass via capacitive coupling. Glass-mounted an-

---

*Antennas that depend on a ground plane work best in the directions where the ground plane is largest.*

---

tennas have become popular because they avoid the need to drill a hole in the vehicle body.

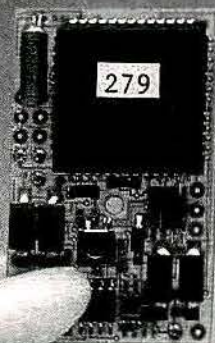
A glass-mounted antenna should be placed near the edge of the roof so as much of the radio energy as possible is emitted above the roof line.

Test equipment can be used to measure how well the capacitive coupling works in each installation. Defrosting wires in rear windows and metal impurities in the glass sometimes interfere with the coupling. Glass-makers sometimes put metal in the glass to make it more clear. Refer to the antenna's instruction sheet for guidance when installing glass-mount antennas on metallic glass or near defroster wires.

Antennas with approximately 3dB gain have become something of a cellular mobile antenna standard. The gain is achieved by stacking two quarterwave sections one above the other. The sections are separated by a phasing coil. In this design, the quarterwave sections are in phase horizontally and out of phase vertically, so the emission is concentrated horizontally.

The 3dB gain antenna comes in roof-mount, magnetic-mount and glass-mount versions. The magnetic-mount antenna is a mobile antenna most

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sued for temporary installations.

The portable antenna is a special challenge for the manufacturer because it does not benefit from the efficiency of a good ground plane.

The portable antenna usually is designed to match the portable telephone's body so that the two components together present a 50Ω impedance at the antenna connector.

A portable telephone often is used in less favorable locations than a mobile telephone, such as inside buildings. When the radio signal passes through walls, much of its strength is lost because of absorption and reflection from the building materials.

A location near a window is better because window glass passes radio energy with little attenuation.

Cellular telephone systems are engineered well. Considering the range requirements, the transmitter power levels and the receiver sensitivity figures, the typical cellular system might be said to be overengineered. Thus, despite the attenuation that building

materials cause to radio signals, portable telephones often work quite well inside buildings.

---

*The portable antenna is a special challenge for the manufacturer because it does not benefit from the efficiency of a good ground plane.*

---

#### Base station antennas

Base station antennas used in urban areas often are designed to receive and transmit in a sector pattern.

The antennas are clustered on a

tower or rooftop, with each antenna serving a section of the surrounding area. Sector antennas with beamwidths as narrow as 60° are common.

A variety of antenna designs make efficient sector patterns possible. Phased dipoles and collinear antennas with reflectors, and log periodic antennas often are used.

Many base station antennas are enclosed in a radome, which is a plastic or fiberglass housing that protects the antenna without attenuating radio signals significantly.

Base station antenna systems include combiners and duplexers. A combiner allows several transmitters to feed one antenna. A duplexer is a filter that separates receive and transmit frequencies. Many channels may be combined to work through one sector antenna.

#### Testing

The first test to perform on an antenna system actually is an inspection.

Look to see whether the antenna is complete and free of mechanical

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breaks or bends. Inspect the antenna connector for any visible problem.

Look for signs of foreign matter deposits and ice or snow on the antenna. Near the ocean, salt spray may deposit salt and other minerals on the antenna that should be washed off with fresh water.

Binoculars can be used to make an initial inspection of elevated antennas

from the ground.

The in-line wattmeter, which displays forward and reflected power, is an indispensable instrument for antenna system testing.

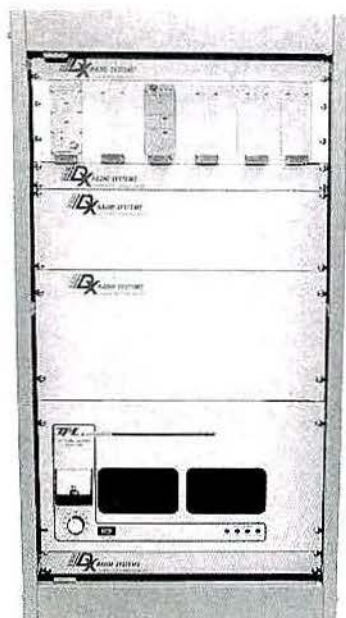
Low reflected power usually indicates an antenna system that works well. High reflected power usually indicates some malfunction in the antenna system.

Keep in mind that because coaxial cable attenuates radio energy, output power measured at the transmitter is higher than output power measured at the end of the cable where it connects to the antenna. Reflected power is greater at the antenna connection than at the transmitter end of the cable.

A multimeter in its ohmmeter mode is an effective mobile antenna system test instrument.

In most mobile antenna systems, a continuity test between the coaxial

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*The in-line wattmeter, which displays forward and reflected power, is an indispensable instrument for antenna system testing.*

connector shield and the center conductor should result in an infinite resistance reading.

With the meter in the same configuration, attach a wire that connects the antenna whip to the vehicle metal. The resistance reading should drop to zero in a good, working antenna system.

### Repair

Antenna system problems occur most often in mechanically stressed components, including the antenna mount and the coaxial cable connector.

The inside of the antenna mount may corrode. If corrosion is found, scrape off the corrosion and dirt with a wire brush.

The coaxial cable is most likely to malfunction at locations where it is subjected to stress. Look for coaxial cable problems caused by sharp edges and heavy objects placed on the cable.

Because antennas are simple devices, most malfunctions can be traced to weathering, corrosion or mechanical stress.

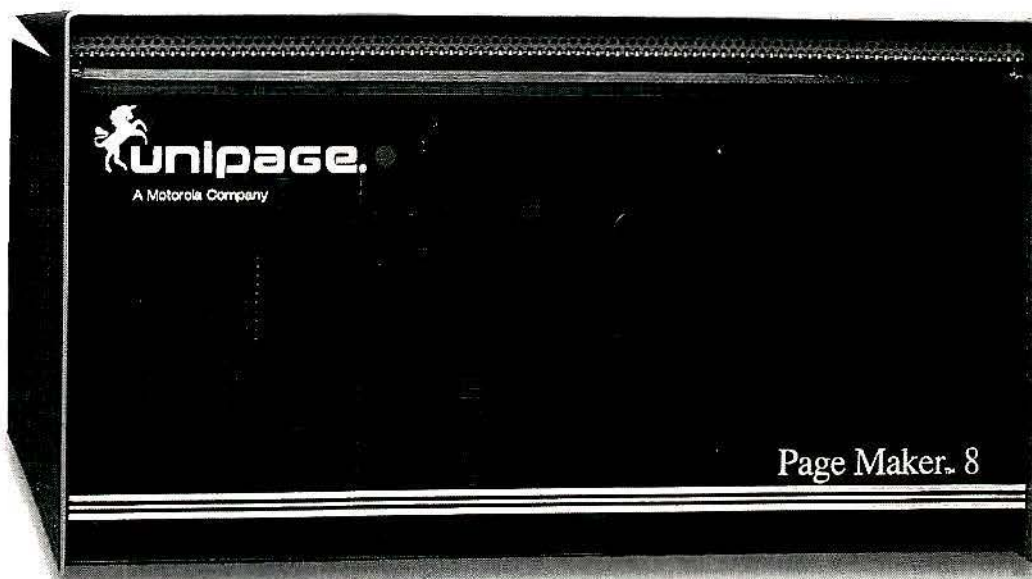
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# Statistical measures for cellular quality assurance

*Expanding cellular systems in MSAs have to find engineering resources to manage rapidly growing functional operations. Statistical performance estimates streamline growth planning.*

By Terry S. Cory, P.E.

Time is the enemy of cellular mobile telephone carriers.

When a carrier fields a new cell on a schedule that averages one per week, there is little time to reflect on the

engineering consequences. As cell spacings decrease in the large metropolitan statistical areas (MSAs), there is an increasing difficulty in keeping interference to acceptable levels.

Nevertheless, for all the time taken by RF analysts and engineers in a typical cellular operating company in col-

lecting and processing drive-test data, the results most often are used on a one-shot basis for diagnosing a particular problem or for deriving data for short-term decisions.

Afterward, the *follow reports* and the

Cory is a consulting engineer in Plano, TX.

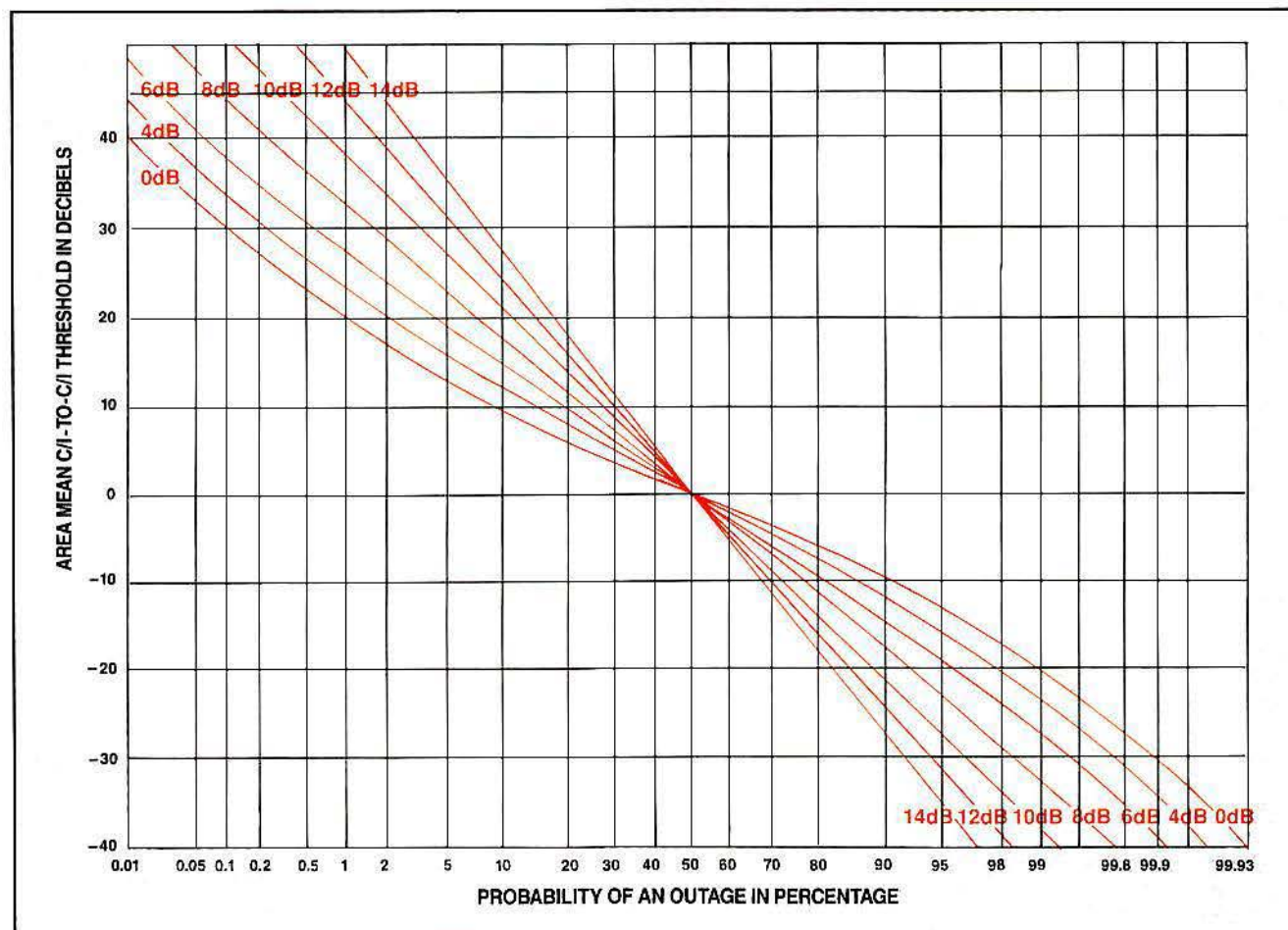


Figure 1. The probability of outage due to lognormal-Rayleigh interference.



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*data plots* are put into files and forgotten. There is little *residual value* to the effort they represent.

Moreover, the data are taken and evaluated on a *deterministic* basis rather than a *statistical* basis. The data, when placed in statistical distributions, are available for predictive performance analysis using a model based entirely on measured data.

Predictive performance analysis *leverages* the time engineers spend as carriers with systems in large MSAs continue to expand their infrastructures.

#### System measures

System measures of *target failures* and *RF losses* are used for quality assurance because they are available

cell-by-cell from cellular switch data.

Although these are good measures of traffic success or failure, a *graded* call quality measure streamlines operations planning and ongoing system engineering maintenance relates data to ongoing subscriber perceptions of true call quality.

A predictor for call success or call quality that normalizes *drive tests* under varying conditions is not readily available as cellular data collection and analysis systems output. Nevertheless, such a predictor would enable expected performance calculation under varied traffic conditions.

Currently, individual drives are used to troubleshoot or to provide engineering decision data for specific items at specific locations within the system. Consequently, these drives form only



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*... individual drives are  
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provide engineering  
decision data for specific  
items at specific  
locations ...*

a snapshot of a time-and-location-varying system in deterministic terms. Fortunately, the drive-test data can be used for normalized call success or call quality prediction.

The RF analyst could use such a predictor to focus on the cellular telephone service's true statistical character. The analyst could assess the mean and standard deviation of the received signal strength indicator (RSSI) or carrier-to-interference ratio (C/I) and the probability of achieving a desired performance level as well as the probability of a dropped or noisy call.

How about measuring C/I on fully loaded channels (signals present on both adjacent and co-channels)? Although measuring C/I is not new, structuring data samples according to occurrence is new to cellular operating companies' engineering regimen.

Why not characterize C/I data

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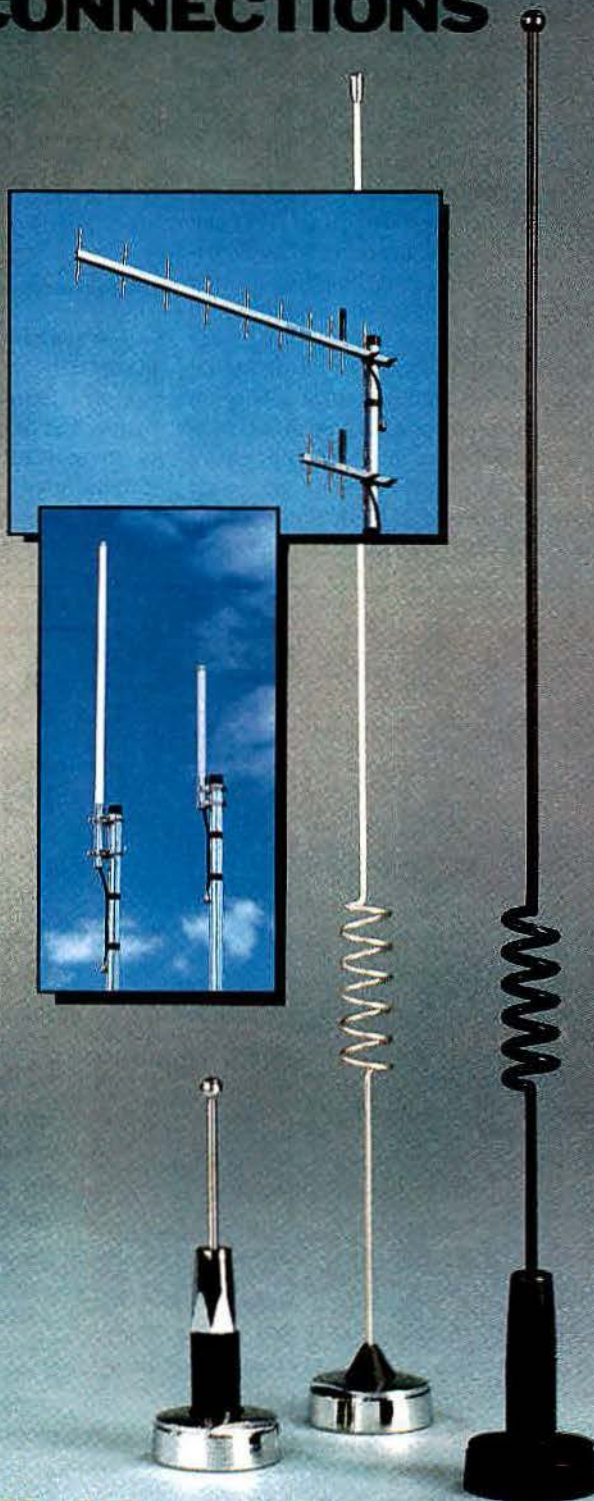
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samples according to occurrence in each of a number of small geographic areas that are operationally significant to the system and not, for example, limited to the best-server area of a particular cell?

The data from a given geographic bin of interest are quantified in increments according to occurrence to give an amplitude probability distribution (APD). The bins can be chosen either on a cell-sector or on a purely geographic basis (a local street map directory index, for example).

The APD for the fully loaded channel gives the worst case. The APD can be multiplied by the probability distribution for traffic, thus enabling system performance predictions vs. time.

Results from a number of cells should tend toward the same APD, with particular measurement sets lying along different portions of this curve. The APDs for a properly operating land mobile radio system are well known, with standard deviations falling in the 5dB-7dB range and approxi-

imating a curve of the lognormal-Rayleigh distribution family.

A program can be written easily to process drive test data and to obtain APDs for the areas being driven. The data file defining the interference plot and producing C/I can be culled to remove non-loaded scans.

---

*... call quality can be assured by adjusting cell site and switch characteristics ...*

---

The remaining data file then can be ordered by counting the number of samples falling within defined incremental C/I ranges. The APD is a graph of these results for the defined geographic area.

Once the APDs have been determined for at least these operationally

significant geographic areas, a model then exists for the system that is based purely on empirical data. If channel loading vs. time from the switch is converted to probability distributions applicable to each geographic bin, then dynamic system performance simulations can be obtained.

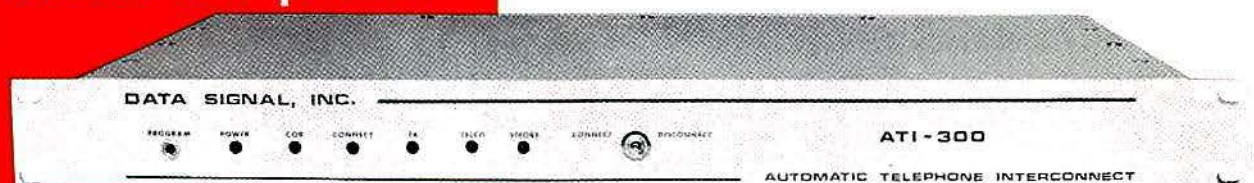
Such a system quality measure distills useful results from all of the *snapshot* drives. The database that progressively builds is continuously available to correlate with new drives as an indicator that there have been no hardware failures in cells serving the test area.

Statistics derived from the APDs will be useful for defining cell performance improvement strategies. Most often within a reasonable range of RSSI variability, call quality can be assured by adjusting cell site and switch characteristics to hand off to the best server before call quality degrades noticeably.

Situations occur, nonetheless, where this adjustment is futile until one or

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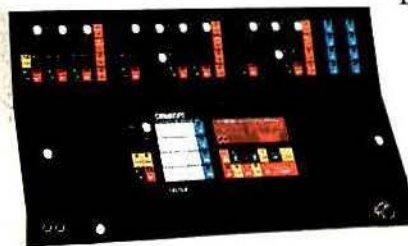
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more particular RF improvements are made. Whereas a standard deviation in C/I of about 6dB is the lower bound with a well-designed cell, a standard deviation upper bound of 12dB will not provide sufficient stability for adjustments alone to solve the problem.

Generally it is difficult to exceed 7dB-8dB based on RSSI or co-channel

components alone unless there is a large system failure or flaw.

The APD will then indicate quickly whether an RF design change is required immediately to improve call quality. Sufficient data must be taken to define the average C/I level when the typical channel is fully loaded.

Often a single drive test is not enough to resolve the question of an

RF design change. The average C/I usually is found as the median or 50% probability value as a matter of convenience in displaying the graph and in normalizing to similar graphs.

Using the APDs makes it impossible to attribute particular C/I levels to dropped calls on a statistical basis over the cell sector (or other small geographic area) for direct correlation with switch data for RF losses.

Lognormal-Rayleigh statistics are shown in Figure 1 on page 22. They are parametric in lognormal standard deviation, with 0dB representing

*Often a single drive test is not enough to resolve the question of an RF design change.*

Rayleigh. The curves are plotted on a lognormal-linear scale. The measured APD curve for the area is expected to fall within this family.

From the APD, a quickly applicable performance measure is available.

For example, assume that an area just meets MacDonald's original service criterion of 17dB C/I over 90% of the area, that lognormal-Rayleigh statistics apply with a standard deviation of 6dB and that the geographic area coincides with a cell's coverage area. Achieving this performance requires a margin of 14dB above an arbitrarily set threshold value of 17dB, which is equivalent to having a median (50th percentile) C/I value of 31dB.

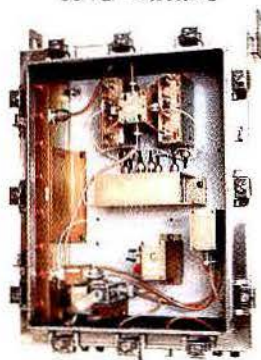
Thus, 50% of the C/I's are greater than 31dB and 50% of the C/I's are less than 31dB. If the call-drop threshold is taken at the lower limit of voice intelligibility for an articulation index of 0.3, then the C/I would be 5dB, a level that would be achieved for 98.6% of the locations. The area mean occurrence rate of dropped calls would be 1.4%.

If the standard deviation were 12dB

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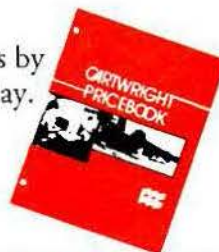
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instead of 6dB, again for a median cell-area C/I of 31dB, then a C/I of only 5dB would be realized for 90% of the locations, and a C/I of 17dB would be expected for only 78% of the locations.

One might argue that the call-drop threshold is less than 5dB, but certainly no less than 0dB. For the 12dB standard deviation, a C/I of 0dB or greater is expected for more than 95% of the

cell locations, corresponding to a dropped-call probability of at least 5%.

For the standard deviation of 6dB, 0dB C/I is expected for 99.5% of the locations, corresponding to a dropped-call probability of 0.5%.

The chances of an outage in the cell fringe areas is greater, typically by a factor of 2-to-3, than over the mean cell area. Using a 2:1 expansion factor

in the fringes, a quick expectation is that dropped calls would occur over 0.5%-1.4% of the area locations and over 1%-2% of the fringe locations. For a 12dB standard deviation, the mean area expectation is that of 5%-10% compared with 10%-20% in the fringes.

Dropped calls certainly are a lower bound on quality assurance, just as achieving a 17dB C/I noise-free call forms an upper bound. Assuming a tolerable noisy signal occurs for a C/I of 12dB (about 25dB SINAD at baseband), the expectations based on the model described above are 95% (90% in the fringes) for a 6dB standard deviation, and 85% (70% in the fringes) for a 12dB standard deviation.

These numbers suggest that a noisy call may be experienced 5% of the time (10% in the fringes) for a 6dB standard deviation and 15% of the time (30% in the fringes) for a 12dB standard deviation.

A quality control question that may be asked is: "For what standard deviation does it become impractical to obtain acceptable performance by adjusting the cell and switch characteristics?"

As a practical matter, adjustment becomes impractical when there is no definite best-server available for the vehicle enroute over the handoff request cycle(s).

At the 90th percentile over the cell area, the Rayleigh curve requires about a 10dB margin to accommodate fast fades. Assume the 31dB median C/I to be a fixed design quantity. Then, if the achievable 90th percentile C/I from any potential server minus 10dB is above the dropped call level (measured or chosen), then the system probably can be corrected by adjustment. This evaluation corresponds to a standard deviation of about 8.5dB, based on minimizing dropped calls.

#### References

1. MacDonald, V.H., "The Cellular Concept," *Bell System Technical Journal*, Vol. 58, No. 1, January 1979, pp. 15-41.
2. Decker, R.P., "Outage Probability in a Log-normal/Rayleigh Environment," private communication, Spectra Associates, Jan. 20, 1983.



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# Testing and repairing older solar panels

*Field service may return solar-powered remote radio communications sites to the air fairly quickly after panel failure. Proper evaluation, tools and procedures help technicians to make repairs.*

**By Donald E. Koehler**

Occasionally, as a technician you may be called to service a dead repeater, only to find the photovoltaics (solar panel) powering the system are inoperative because of vandalism or thermal stress.

Often, a single system or a single repeater is powered by older panels that were bought at a bargain price. When such a panel has minor damage, such as a single gunshot to a cell, or when

the panel has succumbed to thermal stress, it is possible to test and repair the panel on-site.

Although the panel's power output may be reduced somewhat, at least the radio system will be back on the air.

Temporarily reducing transmitter output may allow the repaired panel to be used until a replacement is installed during the next visit to the site. Effecting a repair may be critical if helicopter transport is required or if the site is a long way from the shop.

Older panels are constructed of circular silicon cells covered by a transparent, rubber-like, resilient coating with a fiberglass backing. Some panels may

be covered with a Plexiglas-like material. Others may have a backing of phenolic-like material.

Most newer panels have a metal backing, or the panels are flexible. In most cases, the older panels are easier to repair.

## Tools for testing

The tools needed for testing panels range from simple to complex.

An inexpensive digital voltmeter, a high-quality 0A-8A ammeter and a variable rheostat have been used with success. Analog (pointer) voltmeters are fine, but the digital voltmeter is more suitable. An ammeter with a 0A-8A range is most useful for testing and general system use.

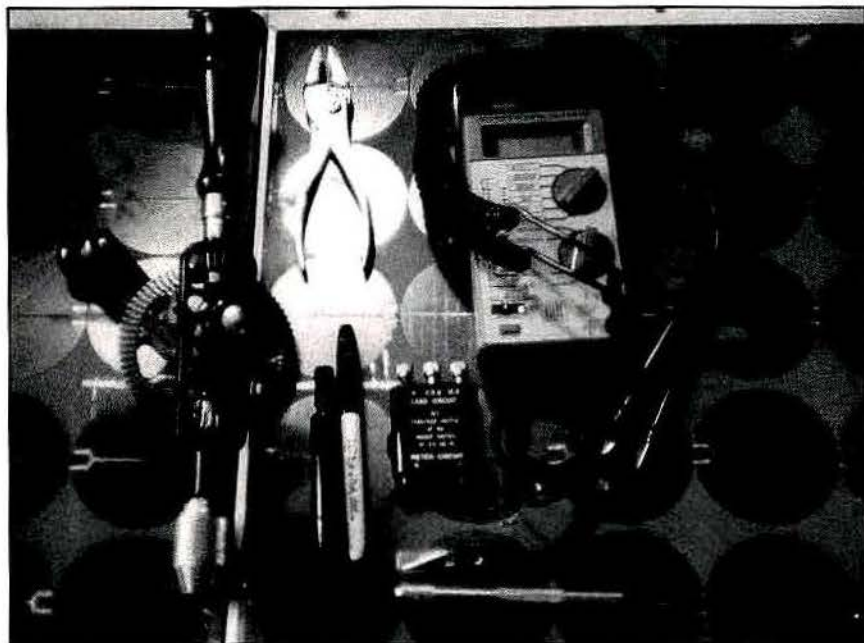
► **Voltmeter**—A shunt allows a common multimeter (volt-ohmmeter or VOM) to be used as an ammeter. Without the shunt, a VOM cannot handle more than a few hundred milliamperes of current before going up in smoke. Shunt construction is explained in the *ARRL Handbook*. Surplus meter movements are available from Fair Radio, All Electronics and JIMPAC.

► **Ammeter**—A resourceful technician can make do with test equipment carried to the site, but a dedicated ammeter is small and relatively inexpensive. It is useful for testing battery-charging subsystems, as well.

Although the ammeter can be made from any old meter movement, it is better to use a high-precision meter to indicate how much power is available from the panel under test.

► **Rheostat**—One rheostat that has been used successfully is nothing more

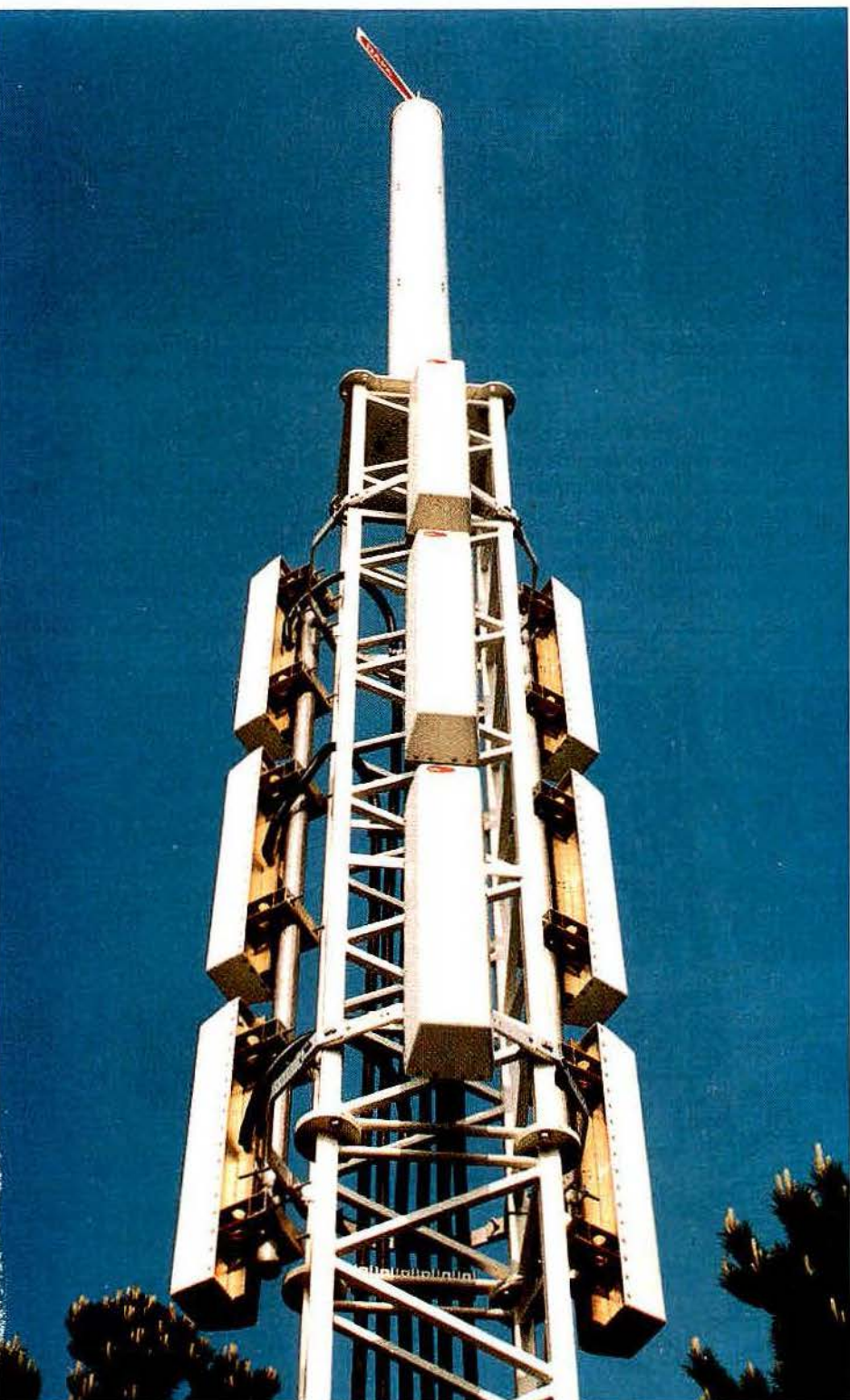
Koehler is a technical writer, technical resource researcher, and computer, communications and database specialist for Hartec Management Consultants, Anchorage, AK.



A few simple tools are all you need to repair solar panels on-site, keeping a system on the air.



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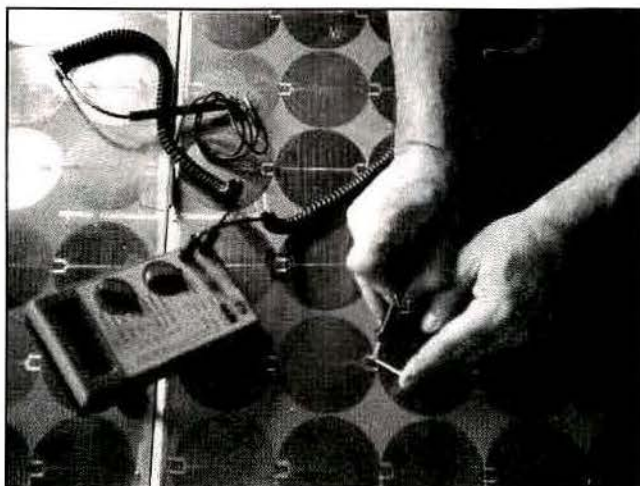
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The meter is grounded via a cliplead. The positive lead goes to a pin inserted through the covering to the foil conductor.



Using an exacto knife, remove the covering over the break in the foil conductor. Be careful to avoid causing damage near the cell.

than a huge, wire-wound variable resistor in a vented case. The power rating is immense, and the unit is a military surplus item.

The rheostat is used as a load for the solar panel during testing and troubleshooting. Alternatively, a lamp or a

speaker coil can be used as a load.

Put the panel under test where you can move it and see the output leads. It helps to know the panel's output rating, but that information is not essential.

Find the output leads and note whether they are marked or color-coded posi-

tive (+ or red) and negative (- or black).

Attach the load across the leads. As far as the load is concerned, polarity does not matter.

For the next step, attaching the voltmeter across the load, *polarity is impor-*

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## The COM-120A

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tant. A digital voltmeter will not be harmed if it is connected backward (reverse polarity), but an analog meter could be ruined. If you are using an analog meter, *be careful*.

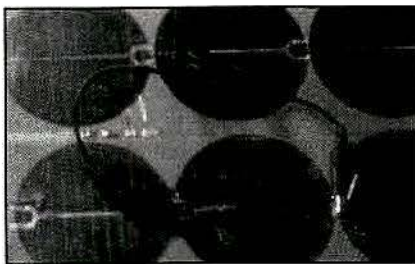
The voltmeter measurement verifies the output lead polarity. If the leads are not marked, now is the time to mark them, and mark them well. If you did not install the system yourself, this step can save you a costly mistake.

Next, connect the ammeter between the panel and the load. Ammeters are *polarity sensitive*, so be sure to connect the positive ammeter lead to the panel's positive lead.

The negative ammeter lead connects to the load and, through it, to the panel's negative lead. In this manner, current flows through the ammeter, through the load and back to the panel.

Connect the voltmeter across the load to measure the voltage produced. Point the panel at the sun and notice whether any current is produced.

Panels with low output current and "normal" voltage are usable "as is."



A suspected faulty cell has been jumpered to restore the continuity of the circuit string under test.

Those with low voltage and current must be repaired.

To troubleshoot older panels, you need the voltmeter and the load. In addition, several long (3-inch or longer) needles, clip leads and a pair of heavy gloves or locking pliers (Vice-grips) are needed. A magnifying glass would be helpful, too.

Connect the panel to the load. Connect the voltmeter's ground lead (— or black) to the panel's ground lead (— or black). With the panel facing toward you, look to see the cell is closest to the

panel ground.

The cells are connected like tiny batteries, some in series strings to boost the voltage and some in parallel strings to boost the current. The cells normally are connected with a foil-like conductor.

When you have found the ground conductor on the cell side of the panel, find the first cell connected to it. With the pliers, insert a needle into the transparent covering until the needle just touches the foil-like conductor above the first cell. Take care not to damage or tear the foil.

Connect the voltmeter's positive lead to the needle with a clip lead. Expose the panel to the sun. If the cell is good, the meter should read about 0.6Vdc. Such a low voltage is read more easily with a digital voltmeter than an analog voltmeter.

If the cell is good, continue up the cell string. As each good cell is added, the voltage will rise about 0.6Vdc.

Several cell strings often are placed in parallel for more current output. You may find an entire cell string good, with

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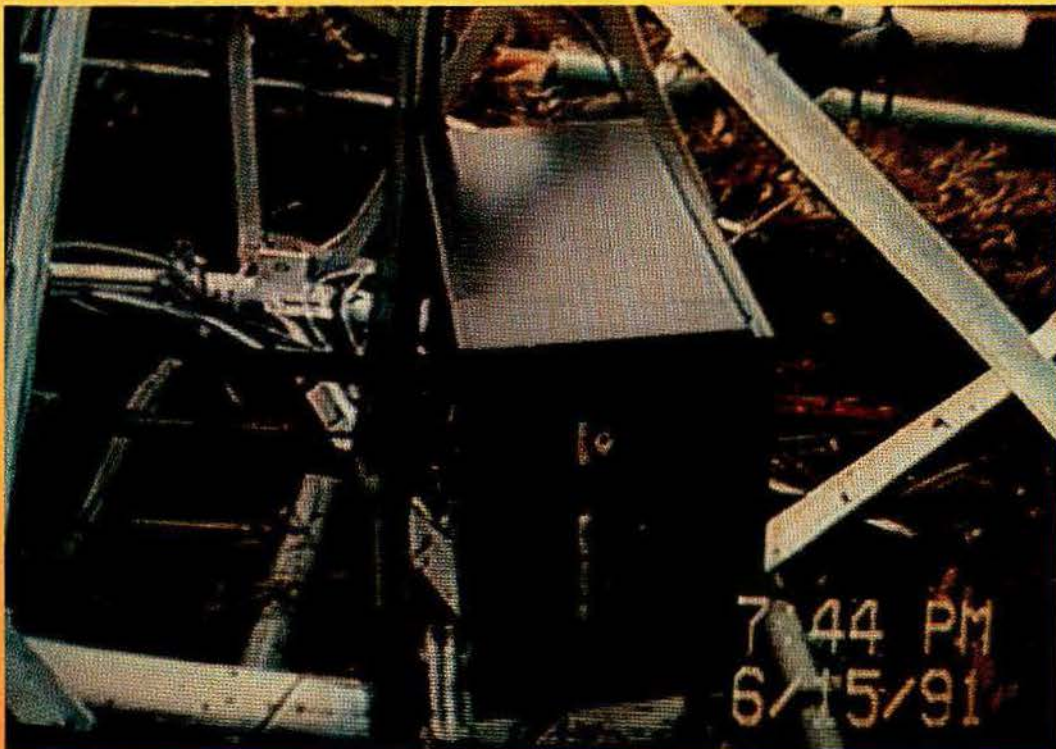
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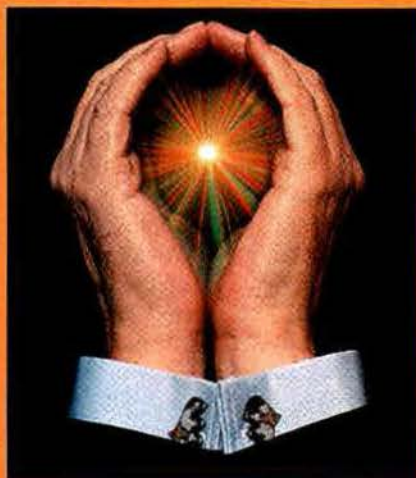
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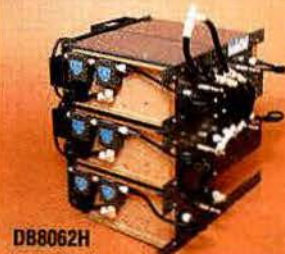
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a bad cell in an adjacent string causing the fault.

When a bad cell is found, place a needle above and below the cell and use a clip lead to jumper around it. Continue to test the panel if the jumper restores the string under test.

Mark all bad cells with an opaque, washable marker. Once all bad cells are marked and jumpered, test the panel

output. This test reveals the worst-case output, assuming the marked cells cannot be repaired.

On panels with plexiglass covering, the needle may have to be inserted from the rear of the panel. Be careful not to damage or tear the foil-like conductor between cells.

A method similar to the one described above may be used for checking other

types of panels. Use common sense.

### Repair

Panels with obvious damage, corroded conductors under transparent covering or backings that are delaminating, rarely are worth the effort to fix.

If the panel has a single gunshot hole, usually through a cell, it may be worth repairing.

Panels with thermal damage usually have several bad spots with no bad cells. Thermal damage may occur when the covering and backing have different thermal coefficients and expand at dissimilar rates, pulling the foil-like conductors from the cells. These faults are tedious but inexpensive to repair.

Repair of older panels is possible, with patience. Additional tools and materials needed include:

- ▶ a pink pencil eraser and/or a small piece of fine-grit sandpaper.
- ▶ a sharp exacto knife or razor blade.
- ▶ a low-wattage soldering iron and low-temperature rosin-core solder.
- ▶ small pliers or tweezers.
- ▶ Crazy Glue or clear fingernail polish.
- ▶ clear silicon room-temperature vulcanizing (RTV), a type of bathtub caulk.
- ▶ a magnifying glass.

I prefer to work indoors and use a 100W spot lamp for panel repair. Repair decisions should be realistic: Is it less expensive to repair or replace, taking system downtime into consideration?

Assuming only one cell is bad, a situation that is uncommon with thermal damage, you can take the following steps. If more than one cell is bad, continue until the job is done.

**Step 1.** In a panel with the older resilient (rubber-like) transparent covering, take your magnifying glass and look carefully at the suspect cell and nearby foil-like conductor. Can you see cell breaks? Is the foil-like conductor lifted from the cell edge or broken between cells?

If the cell obviously is broken (a bullet hole, for example) or if it has major cracks, it is not repairable. Replacing it with a new cell is not worth the effort.

If the cell appears good or if you can see where the foil-like conductor has lifted or broken from the cell or cell edge, odds are you can bring the panel

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back to life.

**Step 2.** Use the exacto knife or razor to make a shallow cut in the panel surface about 0.5-inch square. Use the magnifying glass to get a close look to ensure the cut surrounds the bad spot.

Carefully peel the covering off in small layers. If you hurry, the covering will come off in chunks, possibly breaking a good cell.

Once the cell edge or foil has been exposed, use the knife edge to scrape the last of the covering away from the edge of the foil.

Use a pencil eraser or small piece of sandpaper to buff the area lightly on both sides of the break. If the foil has lifted from the cell, buff the small silver edge of the cell with the pencil eraser.

**Step 3.** Form a solder bridge over the break.

**Warning:** Solder produces toxic fumes. The panel covering produces toxic fumes if heated with a soldering iron. Ventilate your work area. This hazard is common in all electronic repair.

*Remember, the panel backing may not tolerate much heat.*

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Use a small piece of copper wire shaped as a U and tinned with solder to reduce the time the iron spends in contact with the cell under repair.

Remember, the panel backing may not tolerate much heat. Careful preparation and a tinned jumper saves time and damage. You can continue the repair using the tools on hand, applying common sense.

Apply a small amount of solder to the iron's tip—not a big, runny glob, but enough to form a bead that will not drip with the iron held tip down.

Place the U-shaped piece of wire on the area to be bridged. Hold it with the tweezers and apply the iron.

As soon as solder flows, remove the iron. Once the solder cools, examine the bridge with the magnifying glass. If the solder flow did not bridge the gap, apply another small bead of solder.

Do not hold the iron on the work area any longer than it takes to flow the solder. Wait for the area to cool completely before applying the iron a second time.

Test the repair with the voltmeter and sunlight or bright artificial light. If the cell is on line, the repair is successful.

**Step 4.** After the repaired area cools completely, seal it with clear fingernail polish or Crazy Glue—just a light coat.

When the area is dry, apply the silicon RTV to fill in the hole in the panel covering.

Bead the RTV just above the covering. Once it starts to firm up, smooth it off even with the top of the panel covering.

The RTV excretes a mild acid while curing, hence the use of fingernail



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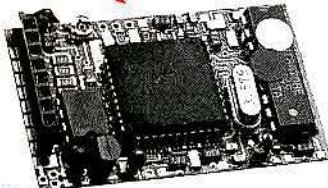
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## Model RT-8X

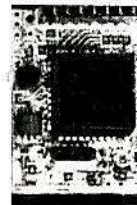


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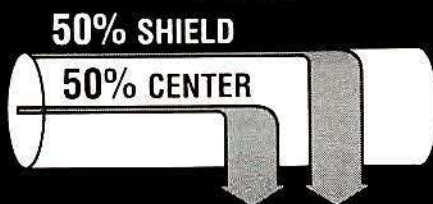
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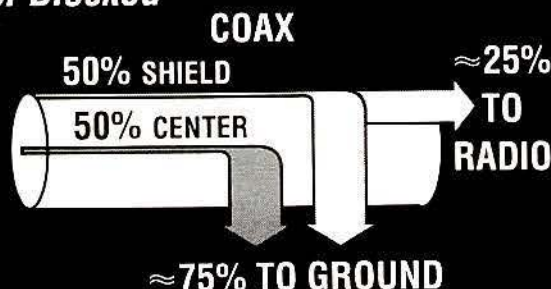
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polish to protect the conductor from corrosion.

This RTV is good to use to fill in holes in the panel covering caused by birds or bullets, assuming the panel is working otherwise.

#### Bypass

It may be possible to bypass a broken cell or a faulty area in a panel covered by plexiglass material. Although it is possible to drill out plexiglass coverings, it rarely is worth the time and trouble.

Instead, turn the panel over to expose the back. Point the panel face to the sun and use the shadow of the cell and conductor to mark the panel's defective area.

Use a *hand* drill to make a small hole into the conductor leading into and away from the cell.

Tin a piece of wire with a large gob of solder, as much as will stay on the wire without dripping when the wire is held vertically. Put the tinned wire into the hole you drilled and heat it with the soldering iron.

Observe the front of the panel and try to see whether the solder flows. Cut wire just above the panel back.

Take the same step with the other side of the cell. Then connect the two wires with a third, insulated wire.

*Note:* Use wire capable of carrying current produced in the circuit.

This jumper is not pretty, but it works.

Test the panel. If it passes the test under load, continue as follows.

Seal the repaired area with fingernail polish. Coat the wire, the holes and the rest of the area.

When the polish is dry, cover the area with silicon RTV.

*Warning:* This repair exposes voltage-carrying conductors from the panel. Cover the area well and protect it from mechanical damage during installation.

Remember, there is no substitute for common sense. Be careful, and if you are unsure about how to proceed, stop. It is better to be safe than sorry.

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# How digital technology will affect SMR operators

*Digital technology will help SMR operators to build wide-area systems that offer competitive mobile telephone service and continue to offer attractive dispatch service. Accelerating subscriber growth is forecast.*

By Robert G. Wysor

Now that the new U.S. president, who was elected on the promise of dramatic change, has been sworn in, the specialized mobile radio (SMR) industry is entering a period of extraordinary change.

Digital technology is the catalyst for restructuring the industry. Digital SMR advantages are spurring a consolidation of system operators, new investment and financing, and a new marketing focus.

Widespread implementation of digital technology will lead to increased subscriber growth, lower SMR radio prices, expanded SMR features and increased radio sales.

The FCC is committed to a regulatory structure that promotes innovation and growth. Digital SMR will provide customers with state-of-the-art features and the possibility to integrate dispatch, interconnect, data, paging and voice services.

Advanced roaming capabilities will be possible with widely implemented digital systems. The management of Fleet Call, a multiple SMR system operator based in Rutherford, NJ, has

stated its desire for a nationwide, seamless digital SMR network. These developments are paving the way for SMR operators to compete with cellular mobile telephone carriers and future personal communications service (PCS) providers.

These developments will lead to an acceleration in growth for the SMR industry beginning in the next few years. The SMR industry has been growing at a rate of about 140,000 new units in service per year since 1985.

The installed base of SMR units has increased from approximately 240,000 in 1984 to 1.3 million in 1993.

EMCI projects SMR growth will accelerate beginning in 1993. Although growth of traditional analog SMR units will remain flat to slightly lower, new digital SMR systems will begin to impact the industry significantly beginning in 1994.

Dramatic change in the growth curve slope is expected, as well as the beginning of non-linear growth for the last half of the 1990s. This change in growth will contrast with the cellular industry's growth pattern, which will be moving from accelerating to steady growth over

the same period. By 1995, the industry will be adding more digital units per year to the installed base than analog units.

Approximately one-quarter of SMR companies plan to implement digital SMR in some form in the next three years. A number of large multiple system operators have filed requests with the FCC to construct large wide-area digital SMR networks. These compa-

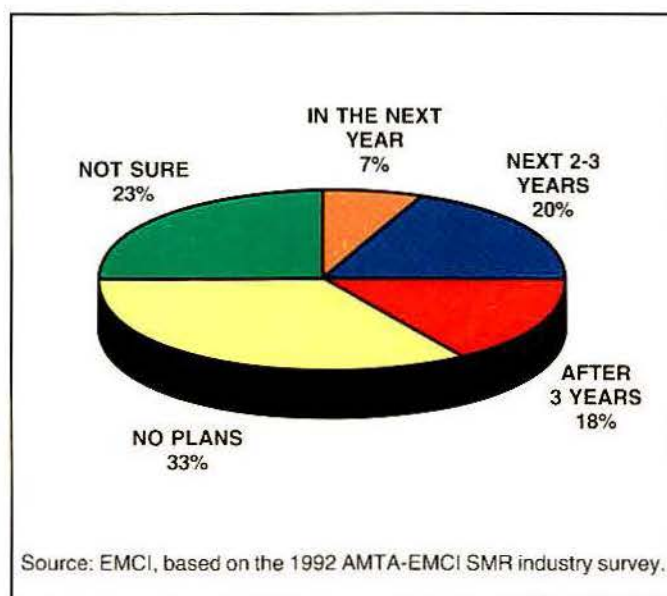


Figure 1. Percentage of SMR companies with plans for implementing high-power digital SMR technology.

Digital growth will be led by Fleet Call and Motorola, Schaumburg, IL, along with a number of other large multiple system operators that are planning to build digital systems. Forward-looking SMR system operators already are implementing wide-area roaming networks even before digital SMR is available. SMR mobile data networks are providing customers with advanced data applications.

Wysor is a consultant with MTA-EMCI, Washington, DC.



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nies include Fleet Call; Advanced Radio Communications Services of Florida, Boca Raton, FL; Advanced MobileComm, Boston; DisCom, Bethesda, MD; Transit Communications, Griffin, GA; and Johnson Communications, Norcross, GA.

Dial Page, Greenville, SC, a large multiple system paging operator, has requested FCC authorization to build a

9-state digital SMR network covering 82 mostly secondary markets in the southeastern United States.

Digital technology will have significant impact on a number of SMR operating issues in addition to increased growth.

► **Interconnection**—The percentage of SMR radios interconnected to the public switched telephone network

(PSTN), which has remained constant at 20% to 25%, will begin to increase.

Capacity gains provided by digital technology will enable companies to expand interconnected service. Interconnected units have a higher churn rate and generate higher monthly revenues per unit than dispatch-only units.

The average churn rate for interconnected units is 3.1% compared to 1.3% for dispatch units. Average monthly revenues per unit are \$49.70 for interconnected units compared to average monthly dispatch revenues of \$15.30 per unit.

► **Prices**—As increased SMR com-

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*Digital technology will have significant impact on a number of SMR operating issues in addition to increased growth.*

petition with cellular service creates downward pressure on radio prices, they will decrease.

Current average SMR radio prices range from \$800 for a dispatch-only mobile unit to \$1,000 for an interconnected portable SMR unit. If SMR radio manufacturers cannot make radios at prices competitive with cellular phones, digital SMR operators may substantially subsidize SMR radio sales prices. At present, 30% of SMR operators subsidize some SMR radio sales.

► **Features**—SMR operators will offer customers expanded feature and service options.

Subscribers will be able to choose from integrated voice, data and paging services. Advanced calling features such as caller identification will become available.

► **Roaming**—Roaming service will become more widespread and easier to use.

Large multiple system operators al-



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ready are forming consortia to establish roaming networks and agreements.

► **Revenues**—The effect digital service will have on SMR revenues is mixed.

Expanded feature and service offerings will tend to increase revenues per unit. Increased capacity will permit more interconnected service. There will be increasing competition with

cellular service, but cellular revenues per unit currently are substantially higher than interconnected SMR revenues per unit, so the impact of cellular competition may not be that great.

► **Radio sales**—Digital growth will lead to increased radio sales.

SMR radio sales are projected to increase from 360,000 in 1992 to 680,000 in 1997. By 1997, approxi-

mately half of new radio sales will be digital.

► **Portables**—The popularity of portable SMR units will continue to increase.

The percentage of portable SMR units in service has increased from 10% in 1989 to 18% in 1992. Portable digital SMR radios initially may be slightly higher than analog portables. Downward pressure on SMR radio prices and operator subsidies discussed above will apply to portable units, nevertheless, and will allow portable sales growth to remain strong.

► **Consumers**—Digital SMR operators will lead the SMR customer base expansion from business customers to consumers.

Companies such as Fleet Call plan to market mobile telephone service directly to consumers, competing with cellular and future PCS operators.

► **Financing**—Increased financing will be available to SMR businesses.

As demonstrated by Fleet Call, large digital SMR systems can attract financing from a number of sources. In addition to industry investors such as Motorola, Fleet Call has attracted outside investors such as Comcast, and has completed a public stock offering.

### Competition

Digital radio technology, which has benefitted from large investments by the cellular industry, is enabling the SMR industry to compete fully in the future mobile communications marketplace.

SMR businesses that take full advantage of digital technology's benefits will be well equipped to lead the industry.

### Source material

Data for this article were taken from EMCI's "The State Of SMR And Emerging Private Radio Markets: 1992-1993."

EMCI's report is based on data collected from the FCC, trade associations, secondary sources, industry leaders and an annual survey of SMR operators conducted jointly by EMCI and the American Mobile Telecommunications Association (AMTA).

The report is available for \$900, except for AMTA members, who may purchase the report for \$600. Contact the author at 202-835-7800.



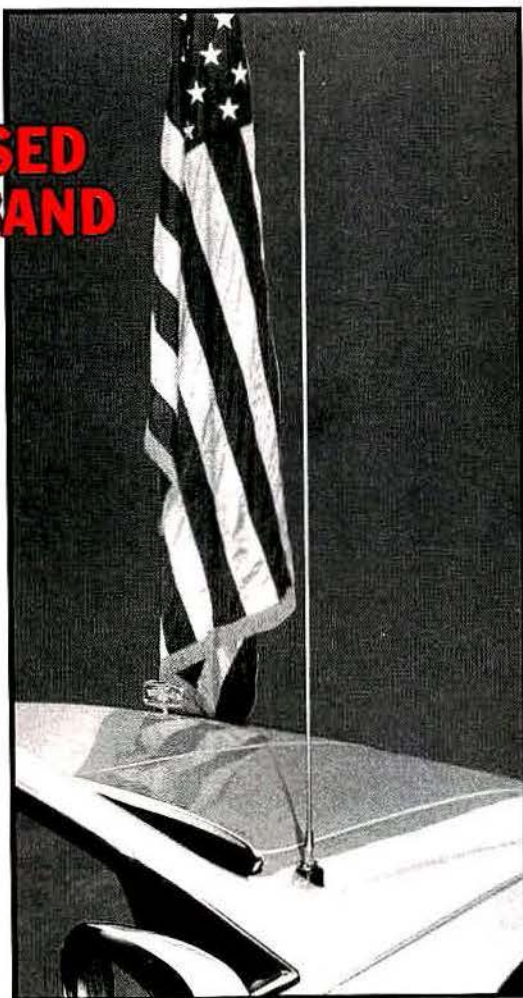
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# Mobile Radio Technology

The journal of mobile communications technology



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# Mobile radio's last 10 years and its future

We asked some of our editorial advisers for their thoughts about the radio communications technological developments of the last 10 years and what may be the important developments in the next 10 years. Here are some of their opinions.

**Herb Sachs, P.E.**  
*Herb Sachs Consulting*

The past decade has seen the real initiation of digital innovations into the analog mobile radio field.

Although mobile radio has not taken

on the digital dimensions of compact discs or Nintendo games, it nevertheless has given us new, practical mobile communications concepts and a glimpse of what may yet come. The two leading innovations of the decade bear this out.

Trunking has come of age during the past 10 years. Led by one industry supplier, Motorola, it initially was accepted skeptically by some people because they believed that the utopian claims being made about it were typical manufacturer super-salesmanship.

But it turned out that trunking really

works, and although it has not been quite the panacea that it has been touted to be, it certainly offers operational flexibility and spectrum savings that never could be achieved on a purely analog basis—assuming you have the cash to buy it.

The cellular mobile telephone explosion has been fed by a population that apparently believes that the equivalent new Ma Bell generation must be even more maternalistic than the last one. The need to be no more than two rings from a phone call has created a market that is quickly engulfing the entire

## How Mobile Radio

*Mobile Radio Technology's* first issue rolled off the press in January 1983.

Borrowed money, credit from a printer and the efforts of three partners brought an idea from a lunchtime discussion to a premier issue containing \$90,000 worth of advertising.

The partners, E. Patrick "Pat" Wiesner, James D. "Jim" Fahnestock and Phil D. Cook, already had decided to start a magazine for the mobile radio industry when they met over lunch in August 1982 to discuss what form it would take.

Wiesner recalled that the three talked about the lack of a technology magazine serving the mobile radio market. "There was *Communications*, a business-industry kind of magazine, and *Telocator*, and not a whole lot else."

Fahnestock recalled: "There were plenty of magazines that told people what color to paint their trucks, and we thought there needed to be a magazine that dealt with the electrons."



**Pat Wiesner**

Having worked at Cardiff Publishing, the publisher of *Communications* magazine, Wiesner and Cook were familiar with the mobile radio industry.

Cook remembered that Wiesner previously had developed an idea for a product tabloid called *Land Mobile Equipment News*, which they discussed. "I didn't favor that format because I wasn't familiar with it," he said.

Wiesner, a physicist by education and an editor and publisher by experience, had experience with technical magazines.

Fahnestock, an electrical engineer with newspaper publishing and book and magazine editing experience, was familiar with the technical side of radio communications.

They quickly settled on a magazine format that would cover mobile radio technology, and the subject matter became the magazine's name.

"Jim and I were technically oriented," Wiesner said. "We thought that we would have good luck with a mobile radio magazine if we wrote about technology because that makes the whole industry run."

"Phil was the selling machine, and Jim was the editor," Wiesner said. "We sold \$90,000 worth of advertising in the first

issue and then never looked back. It was true that the technology idea was very valid."

Wiesner had spent all but \$4,000 of his own money starting another magazine in mid-1982, *Satellite TV* (later renamed *Private Cable*). To launch *MRT*, a venture capital firm lent him \$100,000, and a printer extended credit to print the first two issues.

"*MRT* just kept getting better because of the niche and, between Phil and me, we knew everybody in the industry, and Jim was a very good writer and editor. Things went together to make it work right."

### Fahnestock

In the early '70s, Fahnestock visited Denver seeking work. He wanted to relocate his family from New York to the West.

Among other places, he applied at a publishing company where Pat Wiesner was editor and publisher of *Electronic Design News* magazine. Fahnestock did not find the work he wanted, though he consulted *Electronic Design News* for a while, and he and Wiesner became friends.

Fahnestock owned a computer systems

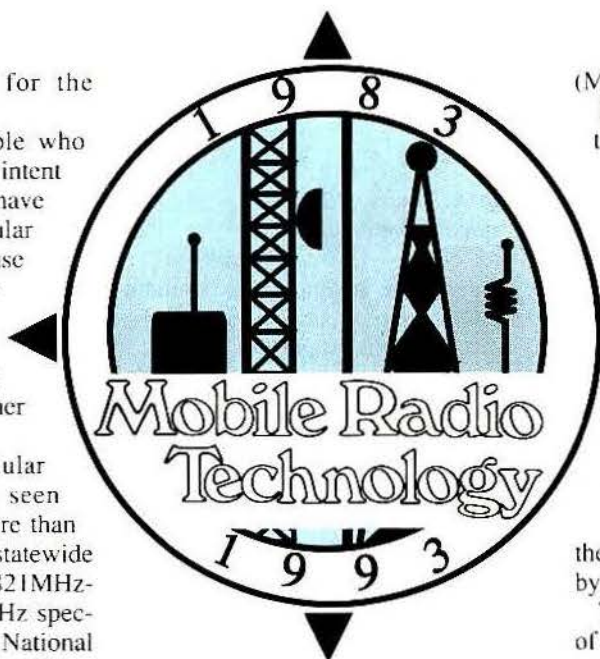


country, except possibly for the Mohave Desert.

Unfortunately, many people who had no real desire, interest or intent in owning a cellular system have gotten rich through the cellular radio licensing process because the FCC offered a federal lottery scheme that gave a helluva lot better odds than state lotteries or Belmont Race Track—but that's another story.

Besides trunking and cellular technology growth, we've seen other activities take hold. More than half of the states now have statewide or regional plans to use the 821MHz-824MHz and 866MHz-869MHz spectrum in accordance with the National Public Safety Planning Advisory Committee guidelines.

Fiber-optics are making inroads in replacing or supplementing micro-



waves as network links, with most applications so far being local cabling.

Regional mobile data terminal

(MDT) networks are emerging.

During the next 10 years, digital technology undoubtedly will reach further into the mobile market.

Count on the further proliferation of computer-aided dispatch systems, an open market for enhanced 9-1-1, the expansion of automatic vehicle location (AVL) through the Global Positioning Satellite (GPS) system and the further tie-in of AVL with computerized mapping, to name only a few of the things to come.

But by far the greatest impact on the mobile radio industry will be made by the new Part 88 of the FCC rules.

The commission, in looking for ways of reconfiguring the spectrum to get more bang for the buck (quixotically called "refarming") has radio suppliers rubbing their hands with glee. The FCC's Part 88 changes will have the

## Technology began

rep firm in New York, and to solve the relocation problem he moved his home and business to the Denver area.

"Around 1980, Pat and I were getting together almost every Friday for lunch," Fahnestock recalled. "We would talk about flying—we are both private pilots. It came about that we talked about starting a publishing company. We kept thinking about possibilities. We both had full-time businesses, yet, whimsically, we kept thinking, 'wouldn't it be neat . . .'."

When the time came to choose whether to join Wiesner in his new publishing enterprise, Fahnestock gave his rep business to one of his associates. He became a partner in Wiesner Publishing, editing *Private Cable* magazine and the new *MRT*.

Several years ago, Fahnestock sold his interest in Wiesner Publishing to Pat Wiesner and retired. He lives in Fort Collins, CO, and enjoys traveling, pursuing his aviation hobby and writing stories for aviation magazines.

### Cook

In 1982, Phil Cook left Cardiff Publishing as vice president and group publisher in charge of *Communications* and *Global*

*Communications* magazines and the company's land mobile trade shows to join Wiesner and Fahnestock at Wiesner Publishing.

Cook recalled that, in the months before starting *Private Cable* magazine, Wiesner had sought financing to start *Land Mobile Equipment News* magazine. "One of the companies that expressed some interest was Intertec Publishing in Overland Park, KS. Pat visited the company and brought a mock-up of the magazine.

"They had several conversations, but Intertec didn't offer him what he wanted," Cook said. "Intertec wanted to own the magazine, but all Pat wanted was financing. Not long after we started *MRT*, Intertec began publishing its own *Land Mobile Product News*, maybe as a coincidence after seeing *Land Mobile Equipment News*."

After about two years, Cook sold his interest in Wiesner Publishing to the other partners and started his own magazines, *Mobile Communications Business* and *Via Satellite*.

He currently sells advertising space at Boris and Sly Associates, Santa Ana, CA, an independent publishers' rep firm that

represents 10 publications that serve the computer industry.

### Update

Intertec Publishing, which competed with Wiesner Publishing and *MRT* for several years by publishing the product tabloid *Land Mobile Product News*, bought *MRT* from Wiesner Publishing in 1986 and discontinued publishing *Land Mobile Product News*.

Cook sold his magazines to Potomac, MD-based Philips Publishing, which converted *Mobile Communications Business* into a product tabloid called *Mobile Product News*.

Pat Wiesner is president of Wiesner Publishing, which publishes six magazines and employs 110 people.

"I have been a part of starting 20 magazines," Wiesner said. "Out of the 20, 10 probably still exist somewhere, and the neatest of all was *MRT*. It is a great magazine, a great niche, and Intertec has done a really good job of carrying the idea forward and making it play well."



most revolutionary effect on mobile radio since Edwin Armstrong opted to move frequency instead of amplitude.

By the end of the next decade, 25kHz channel bandwidths may be virtually obsolete, and analog voice will be following the same path. Very narrowband, spread spectrum and all-digital systems will be commonplace and will be here to stay, and we will

all be looking back at 1992 as "the good old days."

**Gene A. Buzzi, P.E.**  
*President, Omnicom*

Some of the advancements in radio communications technology during the last 10 years that stand out include:

► Radio propagation analysis and determination of coverage have become more accurate and less difficult with advances in computer technologies and greater availability of computerized terrain database information.

► Mobile data terminal (MDT) technology has advanced significantly with increased transmission rates, options for trunking data and the use of laptop computers.

► The integration of digital switching technologies throughout radio communications systems has accelerated the progression of sophisticated networking techniques for real-time communication among a large number of users over a large area. In addition, these technologies have allowed the migration of a vast array of digital devices into two-way radio communications systems.

► Sophisticated automatic vehicle location (AVL) subsystems using Global Positioning Satellite (GPS) and GIS databases provide public safety agencies with incident locations pinpointed to within 60 feet to 100 feet of actual locations.

**Dr. Gregory M. Stone**  
*Senior Associate*  
*Booz, Allen & Hamilton*

Advanced narrowband digital communications (ANDC), such as Motorola's Astro technology, represent the dawn of a new era in personal communications.

ANDC is narrowband, digital two-way communications with embedded signaling and embedded security (COMSEC), which avoids the limitations of hybrid systems with preamble signaling.

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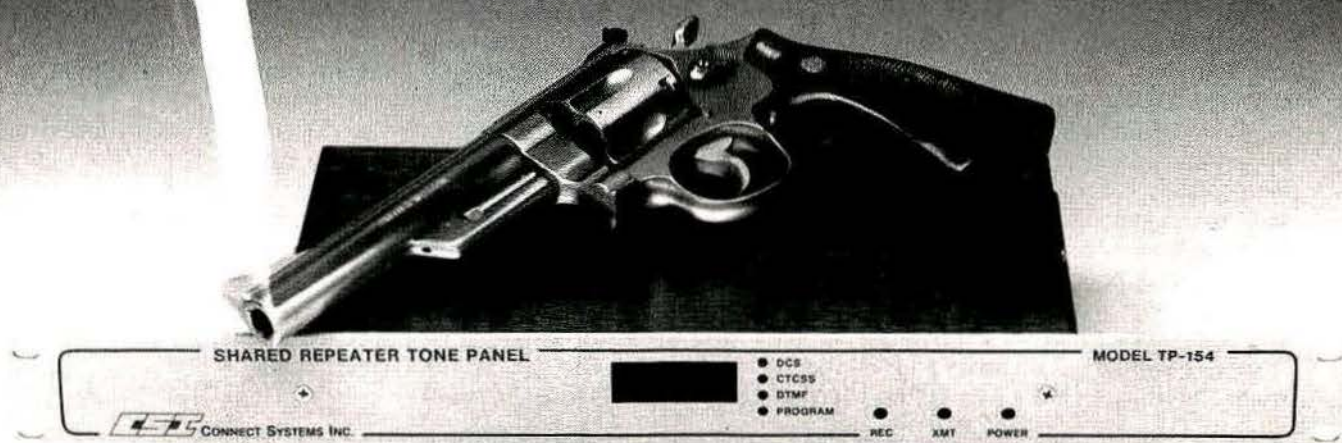
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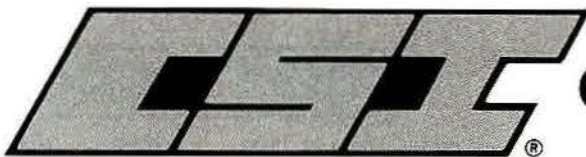
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portable radio that operates on a 5kHz channel with embedded signaling and encryption, the radio could be programmed to do it. Similarly, for interoperability, a software-defined radio could be programmed so that rotating the channel mode or function switch reprograms it to interoperate with a 12.5kHz conventional digital radio system.

One would begin with an ultra-linear direct conversion architecture. Initial RF detection would be accommodated via GaAs-based monolithic microwave integrated circuitry. Electronically configurable direct conversion schemes may be employed.

All modulation and detection would be accommodated at baseband, with the baseband being as wide as necessary to accommodate the required information transfer. For example, I foresee 56kbps or 64kbps data throughput in information bandwidths as small as 2.4kHz in very narrowband FDMA systems. Similarly, adaptive bandwidth allocation schemes may be em-

ploied to provide the required bandwidth for the necessary information transfer rates.

Highly advanced and powerful error and channel coding may be effected and implemented through the use of DSPs operating in the hundreds of MIPS range. Very efficient low-bit-rate vector-based voice coders would provide toll-quality audio at an information transfer rate of 1.2kbps-2.4kbps. Judicious use of DSPs would make this rate possible.

Depending upon the communications or information transfer requirements, different spectrum access modalities may be exploited. Adaptive FDMA systems would be prolific. In highly structured systems or for certain specialized applications such as cellular, air-to-ground, aeronautical and land mobile satellite, TDMA systems are likely to proliferate.

Where maximum spectrum efficiency is necessary or where there are requirements for covert, truly secure communications, CDMA schemes will

be commercially available and commonplace.

**S.R. McConoughey, P.E.**  
*Mobile Communications Consulting*

Some of the changes that have happened to radio communications technology in the last 10 years include:

- The move from transistors to integrated circuits, permitting smaller and smarter radios.

- Programmable frequency synthesizers in two-way radios and pagers meant that they no longer were "rockbound."

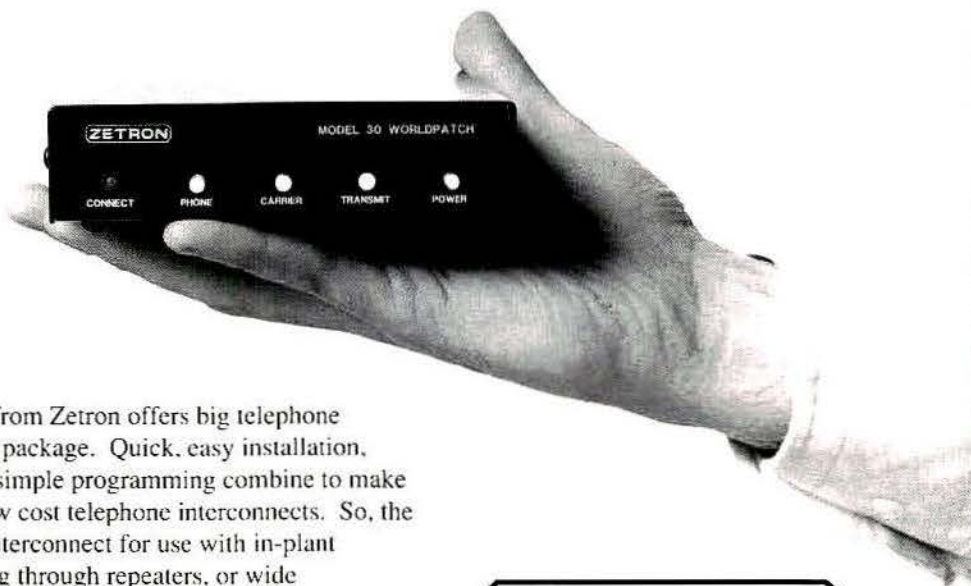
- The move toward trunked radio systems meant better service and spectrum use.

- Smarter and more versatile test equipment.

- New manufacturing techniques combined with application-specific integrated circuits meant smaller portables.

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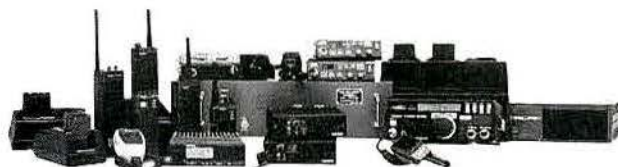
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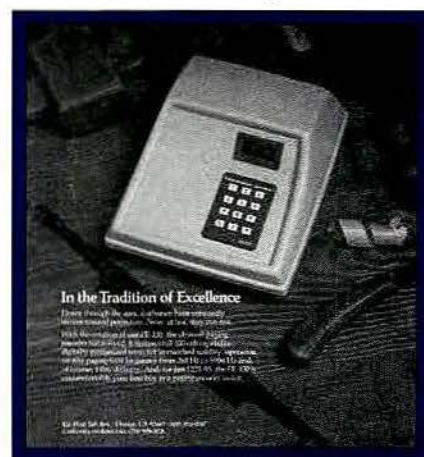
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## Communications Specialists

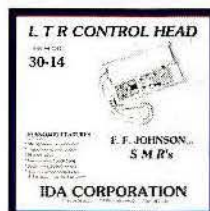


Michael Beveridge comments: "The biggest development in our industry during the past 10 years has been surface mount technology (SMT) into the mainstream design and assembly of radio equipment. Together with microprocessors, SMT allows ever increasing amounts of electronics to fit into ever decreasing amounts of space. This ability assures SMT a big role in the future of our industry and others."

## IDA

Gary Korsgaden notes: "Ten years is a lifetime in the communications business. Big developments in technology seem to come along every other month. I think the most striking development is not in technology but in how the major radio manu-

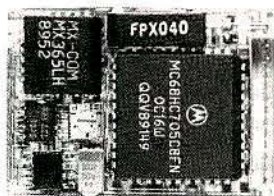
facturers have adapted to the changing marketplace. Some have reinvented themselves quite successfully while others have struggled. I think we all have our personal favorites (biggest technological blunder) but I would hate to name mine! Most of the blunders, and we have our share, have the common theme of painting yourself in a corner engineeringwise. Congratulations to MRT on 10 years of success. The key in the communications business on any level is giving the customers what they want. Those of us that strive for customer satisfaction will always have a market."



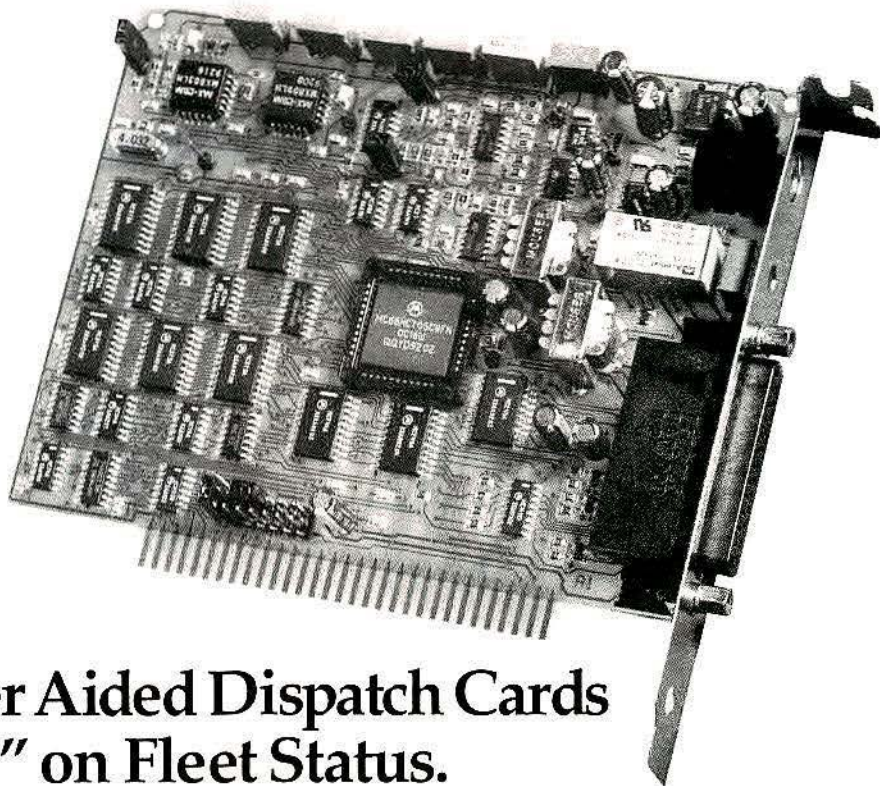


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Steve Rice mentions the Jobcom radio as the biggest technological development and the Hubble telescope as the biggest technological blunder since 1983.

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Tony Martin comments that the biggest technological development since 1983 has been digital communications and the biggest technological blunder was cold fusion. Martin says "MRT accurately reflects the industry—vibrant and growing."

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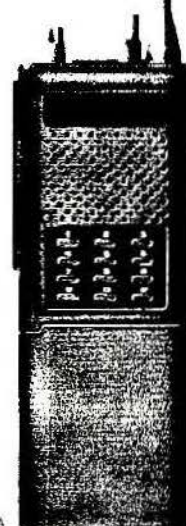
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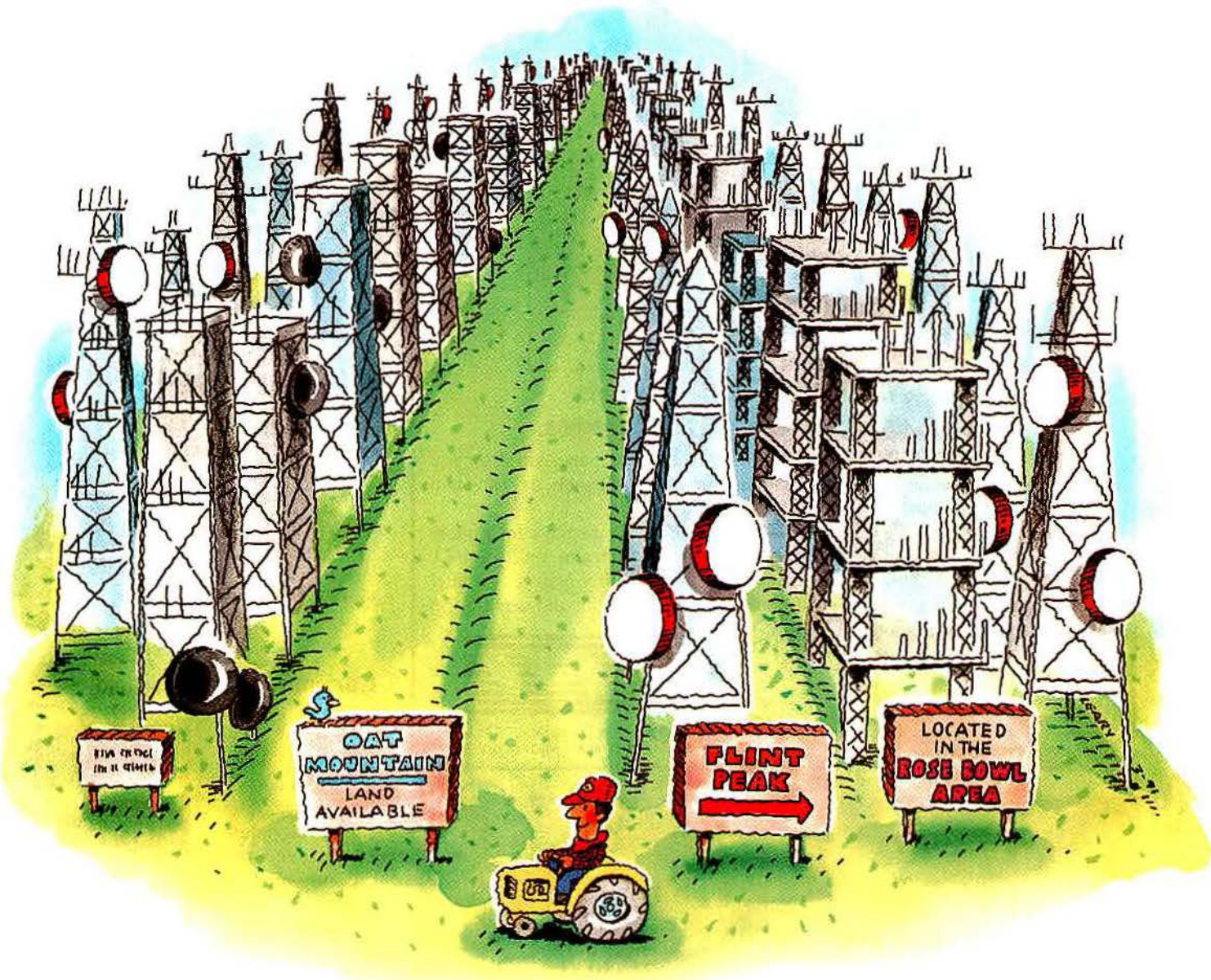
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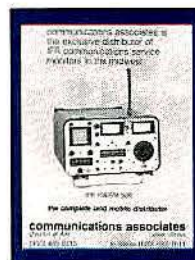
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Jeff Hall remarks that the biggest technological development in the past 10 years is synthesized radios. "Two-way communications continues to grow at an impressive rate. MRT continues to be a good vehicle for industry news and communication with the customer," replies Hall.

## Communications Associates

Chris J. Ryg states "While more of a concept than a technological development. I believe that viewing our industry as 'the mobile communications' or 'the wireless communications' industry has become more prevalent by both industry insiders and observers. This has given our industry more public awareness and business recognition and stature than any of the subparts, such as two-way radio, could have gained. This concept has been made possible by the technological advancements of SMR, cellular, paging and mobile data in the last 10 years. The biggest blunder has been the refusal by some industry participants to recognize the rapid changes that have swept our industry in technology, marketing and customer base. We are only at the beginning of an exciting new era for our industry, particularly as computers and RF equipment begin to merge into new communications products."





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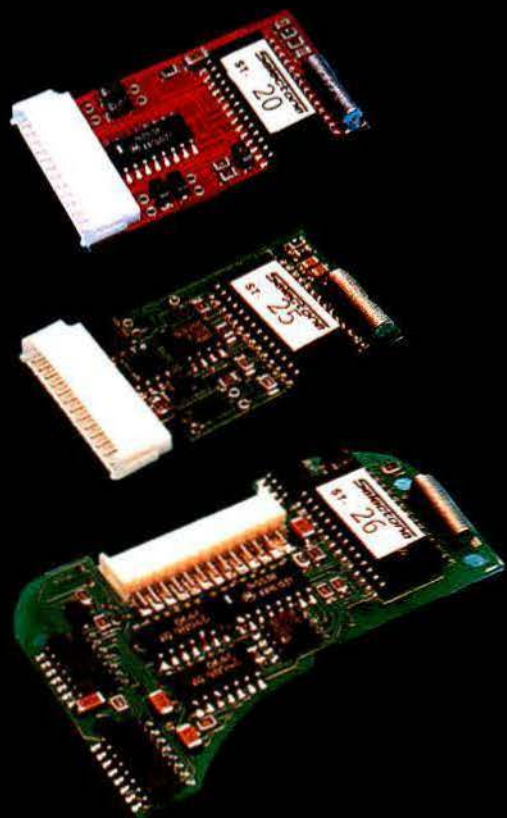
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## Technically speaking

(continued from page 8)

A T-pad also can be used to provide a bidirectional impedance match between two unequal impedances *and* provide an attenuation *equal to or greater than* the loss provided by Figure 1's minimum-loss formula.

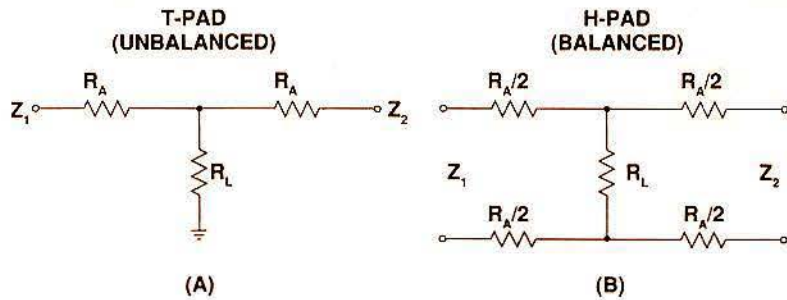
The minimum-loss formula applies to T-pads *only* when the input and output impedances are not equal.

Notice that the T-pad has two arm resistances ( $R_A$ ) and a single leg resistance ( $R_L$ ). The Figure 2 formulas can be used to calculate  $R_A$  and  $R_L$  only when the input/output impedances are equal.

The T-pad is unbalanced. It is symmetrical when the input/output impedances are equal. With unequal input/output impedances, it is asymmetrical.

Important points to remember about a T-pad are:

- (1) It is unbalanced.



If  $Z_1 = Z_2$  then:

$$(4) R_A = Z \left( \frac{K-1}{K+1} \right)$$

$$(5) R_L = Z \left( \frac{2K}{K^2-1} \right)$$

$$(6) \text{ ————— where: } K = 10^{(dB/20)} = \text{antilog } (dB/20)$$

(dB = desired attenuation)

Z = system impedance

Figure 2. The T-pad (A) can be used between equal impedances to provide any degree of attenuation and still maintain an impedance match in both directions. It can be used to provide a bidirectional impedance match between two unequal impedances *and* provide an attenuation *equal to or greater than* the loss provided by Figure 1's minimum-loss formula. The H-pad (B) exhibits all of the T-pad's characteristics, except it is *balanced*.

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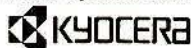
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## Technically speaking

(2) It is symmetrical when the input/output impedances are equal.

(3) It is asymmetrical when the input/output impedances are unequal.

(4) The minimum-loss formula applies with unequal input/output impedances.

(5) The minimum-loss formula does not apply with equal input/output impedances.

(6) It can provide a greater loss than the simple L-pad and still provide a bi-directional impedance match.

### 6dB T-pad calculation

To design a T-pad for 6dB attenuation, use the Figure 2 formulas.

First, find the K factor to use in the formula for  $R_A$  and  $R_L$ .

To find the K factor, use formula 6

in Figure 2. For 6dB attenuation, the K factor is:

$$\begin{aligned} K &= \text{antilog}(6/20) \\ &= \text{antilog}(0.3) \\ &= 1.995, \text{ rounded to } 2.0 \end{aligned}$$

Substituting for K in formula 4:

$$\begin{aligned} R_A &= 50[(2 - 1)/(2 + 1)] \\ &= 50(1/3) \\ &= 50/3 \\ &= 16.7\Omega \end{aligned}$$

Substituting for K in formula 5:

$$\begin{aligned} R_L &= 50[(2 \times 2)/2^2 - 1] \\ &= 50(4/3) \\ &= 200/3 \\ &= 66.7\Omega \end{aligned}$$

### H-pad

The H-pad exhibits all of the T-pad's characteristics, except it is *balanced*.

It consists of four arm resistances ( $R_A$ ) and one leg resistance ( $R_L$ ). (See Figure 2B.) The arm resistances each are one-half of the equivalent T-pad value.

A 6dB H-pad can be made using the above calculations. Simply divide the arm resistances calculated for the T-pad ( $16.7\Omega$ ) by 2 to get the H-pad arm resistance. Thus, the H-pad equivalent is four arm resistances of  $16.7/2$  or  $8.4\Omega$  each.

The leg resistance remains the same,  $66.7\Omega$ .

### $\pi$ -pad

The  $\pi$ -pad exhibits the same characteristics as the T-pad.

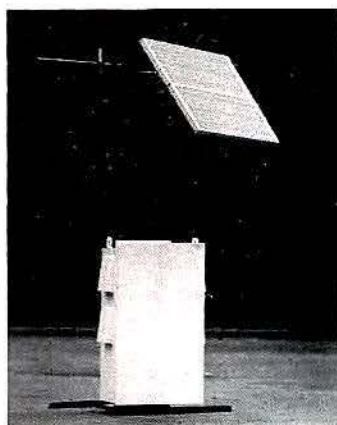
It is called a  $\pi$ -pad because it is shaped like the Greek letter  $\pi$ . (See Figure 3A on page 52.) The Figure 3 for-

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EDACS VPN is identical to the Enhanced Digital

Access Communications System that is already up and running in over 100 communities worldwide. This proven communications is helping customers increase productivity, control fleet operations, and provide non-stop communications during hurricanes, lightning strikes and other emergencies.

When you need proven communications every time, with no interruptions, now you can rely on EDACS VPN.

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**Mobile Communications**

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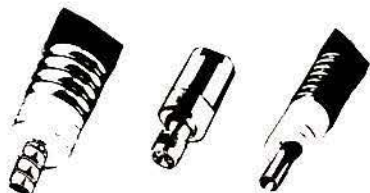


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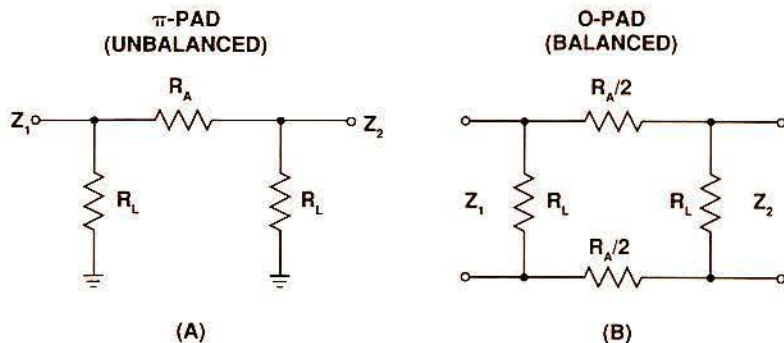
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## Technically speaking



If  $Z_1 = Z_2$  then:

$$(7) R_A = Z \left( \frac{K^2 - 1}{2K} \right)$$

$$(8) R_L = Z \left( \frac{K + 1}{K - 1} \right)$$

(6) \_\_\_\_\_ where:  $K = 10^{(dB/20)} = \text{antilog}(dB/20)$   
(dB = desired attenuation)  
 $Z$  = system impedance

Figure 3. The  $\pi$ -pad (A) exhibits the same characteristics as the T-pad (Figure 2A). It is called a  $\pi$ -pad because it is shaped like the Greek letter  $\pi$ . The Figure 3 formulas apply only when the input/output impedances are equal. The O-pad (B) is the *balanced* counterpart of the  $\pi$ -pad. All other characteristics are the same as the  $\pi$ -pad. The arm resistances each are one-half of the equivalent  $\pi$ -pad value.

formulas apply only when the input/output impedances are equal.

### 6dB $\pi$ -pad calculation

To design a 6dB  $\pi$ -pad, first find the K factor. (See formula 6 in Figure 3). The K factor is the same as it was for the 6dB T-pad design previously shown: 2.0.

Substituting into formula 7:

$$R_A = 50[(2^2 - 1)/(2 \times 2)]$$

$$= 50(3/4)$$

$$= 150/4$$

$$= 37.5\Omega$$

and

$$R_L = 50[(2 + 1)/(2 - 1)]$$

$$= 50(3/1)$$

$$= 150/1$$

$$= 150\Omega$$

### O-pad

The O-pad is the *balanced* counterpart of the  $\pi$ -pad. (See Figure 3B.)

All other characteristics are the same as the  $\pi$ -pad. The arm resistances each are one-half of the equivalent  $\pi$ -pad value.

To design a balanced 6dB O-pad, simply divide the 6dB  $\pi$ -pad arm resistance by 2. This is  $37.5/2 = 18.75\Omega$  for each arm resistance shown in Figure 3B.

Next month you will see how  $\pi$ -to-T and T-to- $\pi$  transformations are used to design and simplify impedance-matching pads.

Construction and testing of resistive attenuator and matching pads also will be covered.





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## N ews

### Shadow Technologies integrates products into custom solutions

Shadow Technologies Group, Lawrence, KS, has formed a radio products line that caters to the law enforcement, forestry and transportation markets. Shadow's customized products integrate well-established product lines from other companies.

Products include transportable briefcase base stations and repeaters in self-contained O-ring sealed, polycarbonate cases; and Chameleon series modular transceivers for body wear. Shadow Technologies is at P.O. Box 442036, Lawrence, KS 66044; 913-749-3566.

### RF Industries plans to open Mexican production facility

RF Industries, San Diego, CA, intends to open a manufacturing plant in Tijuana Baja, Mexico. Currently, 80%-85% of RF Industries' production is handled in the Far East and India. Because the North American Free Trade Agreement (NAFTA) allows goods produced in the U.S., Canada and Mexico to travel freely across their borders, RF Industries will be "bringing product home," according to company president Jack Benz. The joint venture will bring together Far Eastern production and engineering talent with competitive Mexican labor (as compared to Taiwan), thus, according to

Benz, "lowering production costs...and...pouring money into North America."

The new facility will be located 35 miles from San Diego. The plant initially will mold and assemble the company's high-production products. With the Mexican plant, RF Industries' production and delivery time is expected to be reduced from several months to a week or two. Sales, marketing and general administration will continue to be handled in the San Diego office. Plans for the Mexican plant are expected to be finalized by the spring of 1993.

### SIRSA changes name to ITA

During its annual membership meeting in Asheville, NC, the members of the Special Industrial Radio Service Association (SIRSA) approved a name change for the association to the Industrial Telecommunications Association (ITA).

The proposal was presented by outgoing chairman of the board of directors, David W. Lyon. Lyon noted that the fundamental reason for the name change was due to the changes in the communications industry since SIRSA was founded nearly 40 years ago.

"Words such as 'special' and 'radio service' had tremendous significance then; they do not today, and they will be virtually meaningless tomorrow. It is this association's practice to be among the leaders of the private land mobile industry, to recognize trends and to position itself properly within the community it serves. Although a name with tremendous recognition, the term 'SIRSA' may actually hinder the pursuit of our fundamental and strate-

gic objectives," said Lyon.

In his annual report to the membership, Mark E. Crosby, SIRSA's president and managing director, stated: "We need to change our name to properly represent who we are today and to align ourselves with who we need to be during the 1990s...We need a keen awareness of current events, knowledge of our personal and organizational strengths and weaknesses, and the fortitude to act decisively and responsibly to prosper as a viable membership organization."

Officers of the Association for 1993 are: chairman of the board, Andrew J. Pease, Jr., Webber Oil, Bangor, ME; first vice chairman, John R. Walter, Amoco, Houston; second vice chairman, Michael S. Markarian, Newport Harbor, Newport, RI; third vice chairman, Keith R. Knoblock, American Mining Congress, Washington, DC; and president and managing director, Mark E. Crosby, SIRSA, Arlington, VA.



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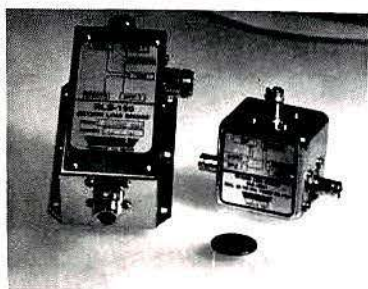
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## News

### Antenna Specialists activates remote bulletin board system

Antenna Specialists, Cleveland, has activated a remote bulletin board system (RBBS) that has technical information and that can be accessed directly via modem. The RBBS provides the latest product specifications; digitized A/S antenna patterns; application notes; trade show schedules; and seminars. The service is free of charge to A/S customers, communication system operators, RF engineers and radio amateurs. The system is accessible 24



hours a day. To use the RBBS, call Antenna Specialists at 216-349-8400.

### Ericsson wins Puerto Rico Electric Power Authority contract

The Puerto Rico Electric Power Authority has signed a contract with Ericsson GE Mobile Communications, Lynchburg, VA, for a multisite Enhanced Digital Access Communications System (EDACS). This represents the first utilities application of EDACS in the Caribbean and South

America region. The 11-site system, to be installed in phases during the next 5 years, will consist of approximately 1,800 MDX mobile and 450 MPA/MTL portable radios, Mastr II and Rangr control stations, operated by a multisite controller with centralized telephone interconnect.

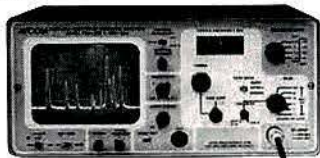
## AVCOM's New PSA-65A Portable Spectrum Analyzer

The newest in the line of rugged spectrum analyzers from AVCOM offers amazing performance for only \$2,855.

AVCOM's new PSA-65A is the first low cost general purpose portable spectrum analyzer that's loaded with features. It's small, accurate, battery operated, has a wide frequency coverage - a must for every technician's bench. Great for field use too.

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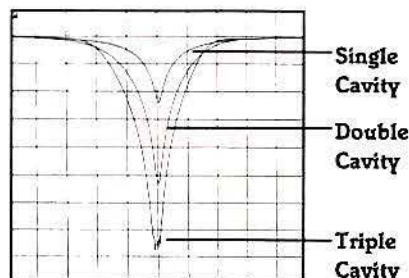
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## TUNABLE NOTCH FILTER

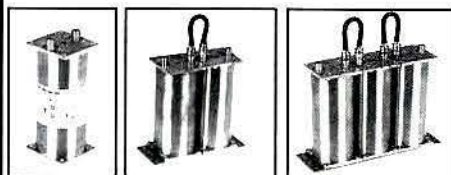
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# It's a small world after all.

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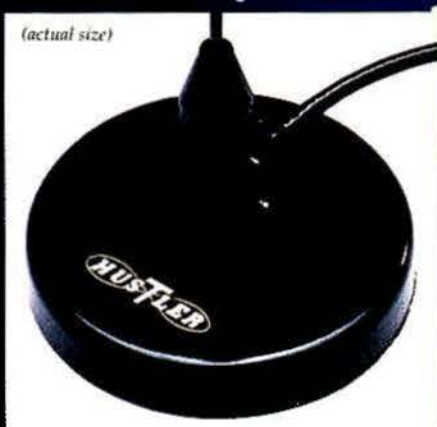
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## News

### Celwave opens Canadian office

Celwave, a Marlboro, NJ-based antenna systems and systems components manufacturer, has opened Celwave Canada to serve Canadian customers. In addition to providing local technical and sales support, the office will continue to support LeBlanc & Royle, the Canadian distributor of Celwave and Cablewave products. Celwave Canada is located at 7305 Woodbine Ave., Markham, Ontario L3R 3V7; 416-940-5530.

### Fleet Call, DisCom merge SMR operations

The boards of directors of Rutherford, NJ-based Fleet Call and Bethesda, MD-based Dispatch Communications (DisCom) have agreed to a tax-free merger valued at approximately \$320 million. Under terms of the agreement, Fleet Call will issue approximately 16 million shares to DisCom shareholders and will become DisCom's sole shareholder. Pending shareholder approval, the merger is expected to close in the second quarter of 1993.

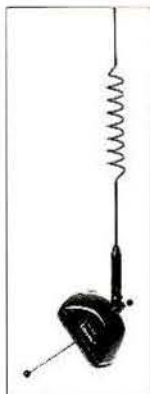
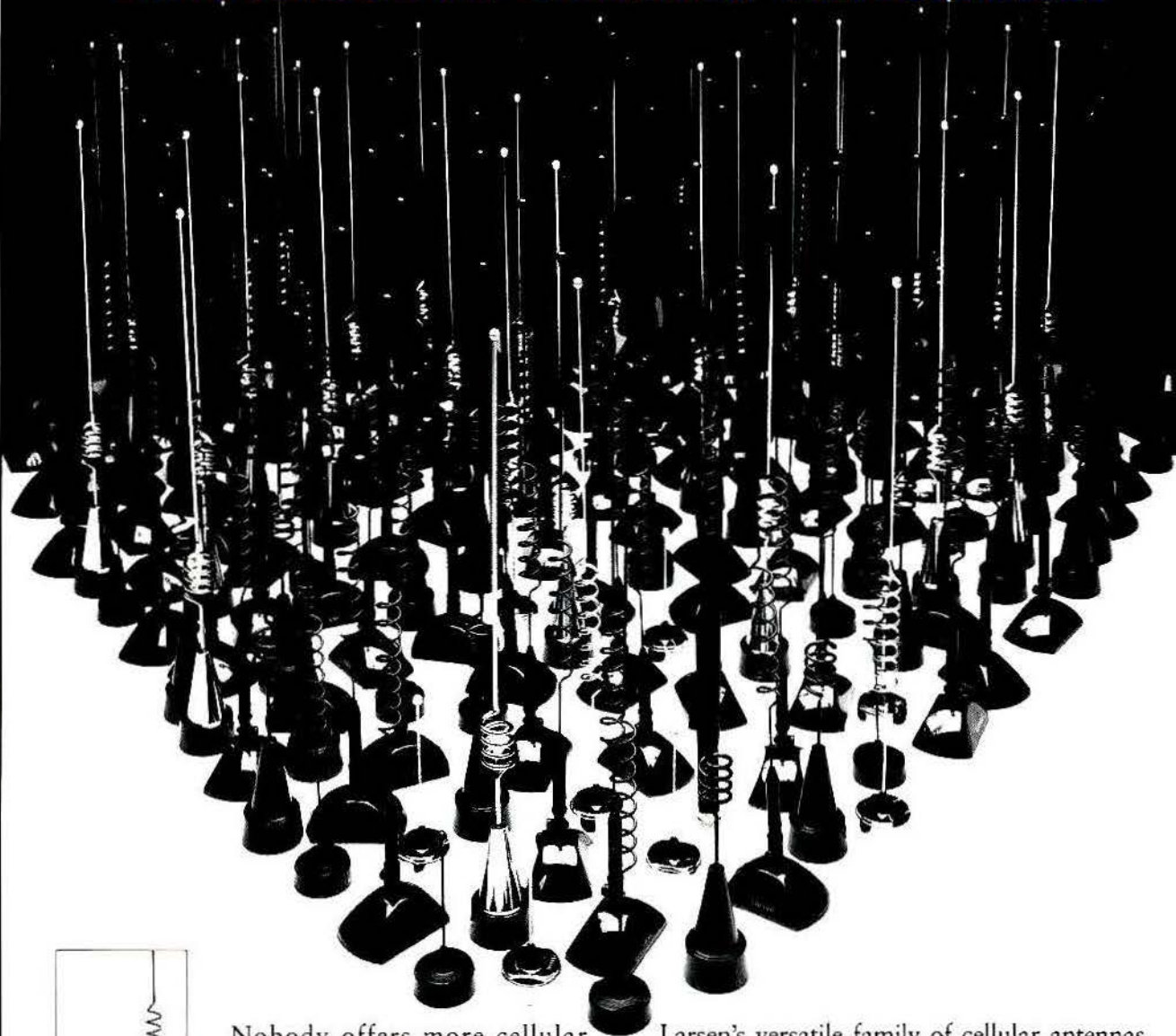
DisCom is the third largest operator of specialized mobile radio (SMR) systems in the United States and leading provider of SMR service in the mid-Atlantic region, New England, Minneapolis-St. Paul and Arizona. Its markets cover more than 31 million people, serving approximately 46,500 subscribers.

After the merger, Fleet Call systems will cover approximately 70 metropolitan service areas (MSAs), including nine of the 10 largest MSAs, covering 95 million people.

"As a result of our merger with DisCom, Fleet Call will be licensed to offer a variety of mobile communications services in areas covering a greater population and more of the 10 largest markets than any other single provider of wireless communications services," said Morgan O'Brien, Fleet Call chairman. "It is another step toward our goal of becoming a major nationwide provider of advanced wireless telecommunications services."



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## News

### Avtec wins utility contracts

Avtec, Gilbert, S.C., has won several contracts to install its advanced color touchscreen integrated radio telephone console system at energy management centers. Locations include DOE Western Area Power Administration, Minnesota Power, Virginia Power, Duke Power, Monogahela Power, East Kentucky Co-op, Central Maine Power, and Georgia Power. These contracts are valued at more than \$3 million.

### Ericsson supplies EDACS system to Kansas City, MO

The city of Kansas City, MO, has signed a contract with Ericsson GE Mobile Communications, Lynchburg, VA, for the purchase and installation of a \$13.7 million public safety communications radio system. The 5-site, 20-channel 800MHz simulcast Enhanced Digital Access Communications System (EDACS) will serve the police, fire and other city departments. Twenty-two C3 Maestro consoles will be at the operations base, next to police headquarters. Another 14 C3 Maestro consoles will be located at an alternative site. Operating on the system will be 1,645 mobile and approximately 1,770 portables. The 9-1-1 communications center is projected for completion in August 1993.

### EMCI projects 2.6 million SMR units in service in 1997

The Specialized Mobile Radio (SMR) industry has been growing at a rate of approximately 140,000 new units in service per year since 1985. EMCI, a Washington, DC-based consulting firm, projects SMR growth will accelerate beginning in 1993. Although growth of traditional analog SMR units will remain flat to slightly lower, new digital SMR systems will begin to significantly impact the industry in 1994. By 1995, the industry will be adding more digital units power year to the installed base than analog units. EMCI has released its annual SMR industry report, "The State of SMR and Private Radio Markets: 1992-1993".



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<b>Output power</b>				
30 minutes:	125 watts	250 watts	900 watts	1800 watts
Surge:	200 watts	500 watts	1000 watts	2000 watts
Motor load surge:			1/2 HP	3/4 Hp
Continuous:	125 watts	200 watts	800 watts	1500 watts
Input Voltage:	10 to 15 VDC	10 to 15 VDC	10 to 15 VDC	10 to 15 VDC
Output voltage:	115 VAC RMS $\pm$ 5%	115 VAC RMS $\pm$ 5%	115 VAC RMS $\pm$ 5%	115 VAC RMS $\pm$ 5%
Output frequency:	60 Hz $\pm$ 0.01 %	60 Hz $\pm$ 0.01 %	60 Hz $\pm$ 0.01 %	60 Hz $\pm$ 0.01 %
Output waveform:	modified sinewave, phase corrected	modified sinewave, phase corrected	modified sinewave, phase corrected	modified sinewave, phase corrected
Efficiency:	Approx 90%	Approx 90%	Approx 90%	Approx 90%
No load current draw	< 70 mA	< 150 mA	< 300 mA	< 600 mA
Low battery alarm:	10.7 V	10.7 V	10.7 V	10.7 V
Low battery shutdown:	10 V	10 V	10 V	10 V
Dimensions (HxWxL):	1.5"x 4.5" x 4.5"	1.5"x 4.5"x 6"	(3" x 9" x 10")	(3" x 9" x 16")
Weight:	1.13 lbs	1.25 lbs	5.25 lbs	8.25 lbs
<b>Protection features:</b>				
Over temperature:	Electronic Shutdown	Electronic Shutdown	Electronic Shutdown	Electronic Shutdown
Overload:	Electronic Shutdown	Electronic Shutdown	Electronic Shutdown	Electronic Shutdown
Short Circuit:	Electronic Shutdown	Electronic Shutdown	Electronic Shutdown	Electronic Shutdown
Reverse polarity:	Fuse	Fuse	Fuse	Fuse



## Telocator study shows PCS licensing by 1994 could bring 23 million subscribers by 1997

A demand forecast by the Telocator, Washington, DC, Personal Communications Service (PCS) section shows that if the FCC licenses new PCS providers by 1994, there could be as many as 23.3 million subscribers within three years.

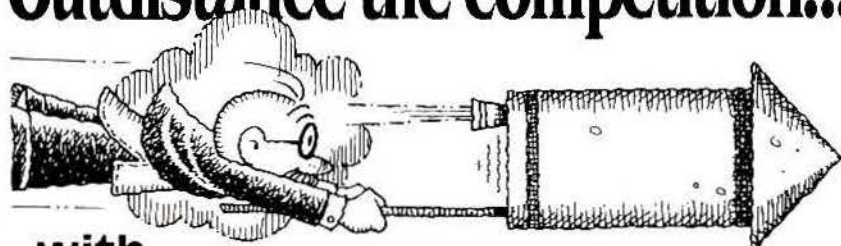
The forecast lists potential subscri-

ers in three areas: Telepoint/Advanced Telepoint (5.6 million), Personal Telecommunications Service (9.4 million) and wireless PBX (8.25 million). The document predicts the same services growing to 56 million by 2002. Competitive services such as paging, cellular, and SMR would grow from a cur-

rent base of approximately 21 million to 62 million subscribers in the same time frame, assuming PCS licensing in 1994.

The demand forecast was produced by the Consumer Requirements Subcommittee of Telocator's PCS Marketing and Consumer Affairs Committee, one of the three standing committees in the section through a "Delphi" study of companies holding membership in Telocator's PCS section. These include CPE manufacturers, LECs, cellular carriers, research organizations and entrepreneurs.

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### Interstate Power selects E. F. Johnson system

E. F. Johnson, Minneapolis, will build a Multi-Net trunked radio system for Interstate Power. The system will operate from 37 repeater sites in four states—Illinois, Wisconsin, Iowa and Minnesota. When the system is completed, Interstate Power crews will communicate through more than 300 mobile and 50 portable radios. Two E. F. Johnson dispatch consoles will be installed at Interstate Power's power control center in Dubuque, IA.







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## 800MHz wide-area SMR system waiver applications continue to flow

By Alan S. Tilles, Esq.

The FCC Private Radio Bureau has placed a moratorium (a *freeze*) on the acceptance of specialized mobile radio (SMR) system license applications with proposed transmitter sites closer

than 75 miles (*short-spaced*) from existing or already applied for co-channel transmitter sites.

The freeze was announced after the bureau received a large number of applications for 800MHz wide-area digital SMR systems that included requests that the FCC waive its 75-mile

transmitter separation requirement based on a controversial technical definition of acceptable interference between close-spaced stations.

Despite the freeze, the FCC continues to receive applications for licenses to build wide-area digital SMR systems. Although these applications request that certain rules be waived to facilitate the construction of the systems, they do not involve short-spacing. Among those filing the additional applications are American Mobile Systems for transmitter locations in Florida and Powerfone for transmitter locations in Detroit.

On Dec. 23, 1992, the bureau sent a letter to the National Association of Business and Educational Radio (NABER) and several SMR licensees that responds to their questions about the definition of mobile loading and footprint.

(Loading refers to how many mobile units use a radio channel. Footprint refers to a radio coverage area. NABER is an Alexandria, VA-based trade association that represents SMR licensees and other radio communications interests.)

The questions arose because the recent applications for wide-area digital SMR systems rely on interpretations of mobile loading and footprint that are more liberal than some SMR licensees want. The effect of the liberal interpretations would be to allow the construction of new SMR transmitters in locations that might not be allowed under a more stringent interpretation.

In the FCC's *Report and Order* in PR Docket No. 92-79, Footnote 30 reads that the commission "will credit individual SMR systems with all end users in their business records, including those end users who do business with more than one system." Some SMR licensees and applicants think that means that a single mobile unit can be counted, for loading purposes, on more than one system, if that mobile unit were "doing business" with more than one system.

Tilles, MRT's regulatory consultant, is a partner in the law firm of Meyer, Faller, Weisman and Rosenberg, P.C., Washington, DC.

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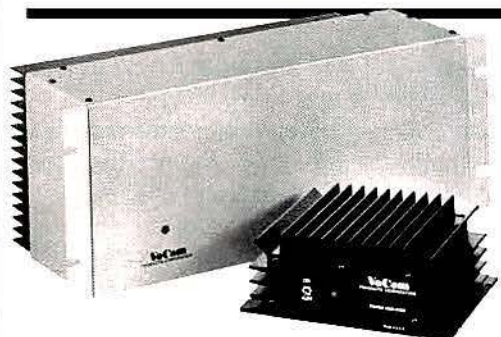


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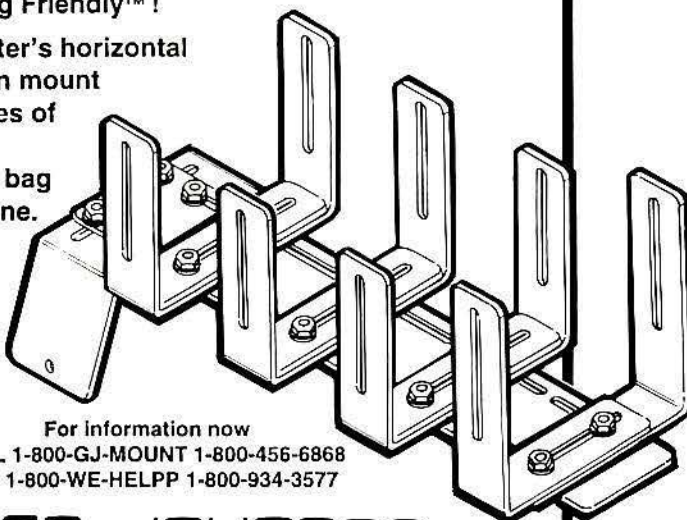


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## Regulating technology

Several of the new wide-area SMR system applicants requested channels in areas not served by their current systems and claimed full loading for the proposed systems based upon mobile units loaded on their other systems. This situation led the bureau to consider clarifying the footnote to avoid what some saw as an absurd result—counting a mobile unit operating in New York for loading in Los Angeles, for example.

Actually, though, the bureau's Dec. 23 letter takes an even more conservative approach than the original rules. Specifically, the letter reads that "an applicant may count a single mobile/portable once, and only once, for one SMR system, wide area or not."

Although the letter's loading definition seems to be consistent with the footnote, the letter goes on to read that the commission considers a "system" to be SMR stations "commonly owned or managed systems or participants in a common roaming agreement." The FCC will give multiple loading credit "where the system operators would have no reason or opportunity to be familiar with each others' business records."

In other words, if Operator A owns a station in Chicago and manages a system in Milwaukee, and an SMR unit genuinely operates on both systems, the mobile counts for loading one time.

If, on the other hand, Operator A owns the station in Chicago; Operator B owns the station in Milwaukee; Operator A and Operator B do not have a roaming agreement; the mobile unit is programmed on both systems without Operator A and Operator B knowing about the other; the commission will permit multiple loading counts.

In its comments filed with the commission in PR Docket No. 92-79, NABER specifically warned about the potential abuse of multiple loading counts. In addition, the trade association objected to the FCC's proposal to use a 6-month average test because licensees would have to meet a 4 1/2-year loading test instead of a 5-year loading test. Furthermore, a licensee would have a fully loaded, congested system for six months before becoming



ing eligible to apply for additional channels.

Subsequent to the *Report and Order* in PR Docket No. 92-79, FCC employees explained that the ability to count mobiles on every system on which the mobile operates mitigated the effects of the 6-month test. With this in mind, they said they thought that the new rule, as interpreted at the time by the FCC, was sufficient to limit abuse and to not penalize genuine operators.

Unfortunately, SMR licensees operated for four months under the "multiple count" interpretation, and it may be difficult for them to readjust their business plans and to reconcile the expenditures they made.

Nevertheless, NABER and an ad hoc group of SMR licensees continue to work with the Private Radio Bureau to sort out the rapidly changing regulation.

\* \* \*

### Refarming concerns

The private radio industry's initial review of the FCC's proposed rulemaking to *refarm* its spectrum is mixed.

Refarming refers to changes in technical requirements and channel assignments intended to fit more users into existing radio spectrum without materially increasing interference. It includes a conversion of some channels from shared use to exclusive use by a single licensee in a given area. Some of the exclusive-use licensees would be permitted to sell radio communications service to others, as SMR licensees do.

Although many people praise the proposal to permit exclusive-use overlays and the commission's efforts to ensure that paging channels continue to operate at high capacity by excluding them from its proposal to impose narrower channels, others question how the mechanics of the conversion will work.

For example, the requirement to reduce FM transmitter frequency deviation in 1996 to confine the radio signal within a narrower channel may increase the radio noise on some exist-

ing systems enough to render them useless in some areas they now cover.

Moreover, it is uncertain whether mobile equipment for the first phase of the channel-splitting (a narrowing of the channels) will be made available.

Several mobile radio trade associations have established committees to review and analyze the FCC rulemaking proposal, which, by the

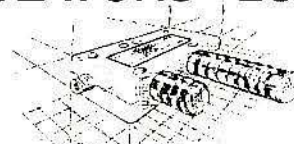
way, includes some tinkering with rules governing the 470MHz-512MHz and 800MHz bands that was not originally advanced in the *Notice of Inquiry* that preceded the rulemaking proposal.



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## Readers' choice

Of all the new products and services in the June 1992 issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact Card number on the card found in the back of this issue and mail the card to us.

### Hand-held receiver covers 500kHz to 1,300MHz



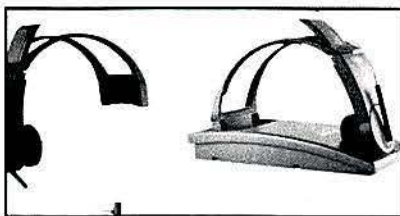
The AR1000XC hand-held receiver boasts 1,000 channels and a 500kHz-to-1,300MHz coverage range. The **Ace Communications** unit has 26 front-panel keys for programming 1,000 scan memory channels; and pairs of upper and lower limits for bands to be

searched can be stored in 10 search memory locations.

Circle (501) on Fast Fact Card

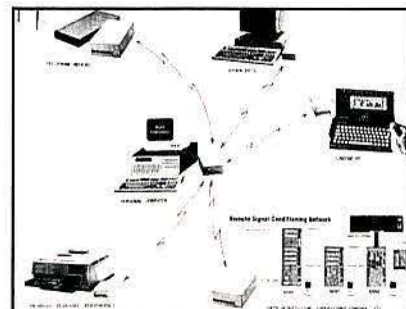
### Cordless headset works 50 feet from base

A 900MHz cordless headset from **Hello Direct** includes a separate battery pack and radio transceiver that allows movement as far as 50 feet from the base. The unit boasts 32 channels and features an adjustable listening volume control and a noise-canceling mic.



Circle (502) on Fast Fact Card

### Packet radio modem transceiver provides secure transmission



Model 5100 spread-spectrum packet radio modem transceiver from **Solid State Electronics** provides secure two-way transmission and reception of digital data. The unit can be used as a wireless modem for PC communications within a building or as a data link to isolated or inaccessible areas.

Circle (500) on Fast Fact Card

### Computer program furnishes technical information

The Sentry Service Manager provides service information, charts and more than 20 formula computation and conversion screens on disk to aid technicians in their repair work. The program from **Sentry**

**USA** operates on IBM-compatible computers and uses 750 kilobytes on the hard drive. The program is available on 1.2-megabyte 5.25-inch or 1.44-megabyte 3.5-inch high-density disks.

Circle (350) on Fast Fact Card

### Digital microwave equipment uses high-power amplifier

The ProLine Super family of microwave 45Mbps and 34Mbps 15GHz digital radios with high power amplifier from **ATI** offers increased power output and a range as far as 20 miles. The ATI 4/8 DS1/E1 features four levels of loopback: local, cable, remote and external; dip-switch equaliza-

tion for interconnect cables between indoor and outdoor units; optional digital service channel and orderwire with digital voice channel and RS232 data port; and digital interface unit requiring no adjustments.

Circle (351) on Fast Fact Card

### Soldering station provides positive tip feedback

The digital temperature control soldering station from **M. M. Newman** operates on 115Vac and converts line voltage to



24V and provides positive tip temperature feedback. The Antex TCSU-D2 features dial selectable temperatures; 50W soldering iron with a positively grounded tip and thermocouple; and a 4-foot burn-proof cord with a 5-pin DIN connector. The unit meets MIL specifications.

pin DIN connector. The unit meets MIL specifications.

Circle (353) on Fast Fact Card

### Logger offers instant access to operating commands

**Stancil** offers a VHS 24-hour logger that has a fully animated graphic screen display and advanced software design. Features include four to 32 tracks; eight operating buttons; and single or failsafe dual decks in a rack-mount or desktop. The logger is designed for use in parallel, serial or redundant system configurations.

Circle (352) on Fast Fact Card



### Insurance covers lightning strikes

**Tripp Lite's** UPS systems feature lifetime insurance that provides for the repair or replacement of connected equipment damaged by a surge, including direct lightning strikes. The systems are available 250VA to 4,400VA in stand-by, on-line and voltage-regulated configurations. The insurance coverage is also included on its Isobar surge suppressors.

Circle (354) on Fast Fact Card



### Clip-on antenna boasts 5dB gain

A clip-on coupler for the Oki 900 provides an external antenna for better transmission and reception, and an energy electro-coupler to connect the antenna

cable to the phone. The coupler from **Mobile Mark** pushes onto the phone's antenna. The clip-on antenna slides on and off the ear door window, the whip is

outside the car, and the cable is inside the car so the window rolls up completely.

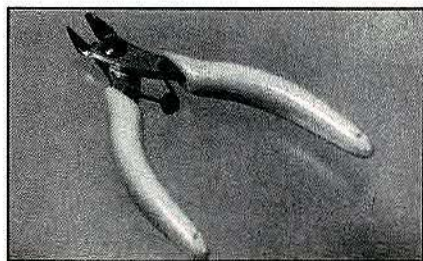
Circle (355) on Fast Fact Card

### Paging package improves alphanumeric service features

Page Companion, a hardware and software package from **Real Time Strategies**, provides automatic subscriber-requested page retransmission based on missing sequence numbers or time of day; addition of sequence numbers to numeric or alphanumeric display pages; operator-based retrieval of subscriber pages; repeat paging until canceled by subscriber; time of day paging; TDD-compatible alphanumeric paging; and optional voice retrieval of textual messages. The package includes a 385-based PC, four end-to-end telephone trunks, four TAP input ports, two TNPP links, one host paging terminal interface port and a remote diagnostic port.

Circle (356) on Fast Fact Card

### Plier kit features stainless steel instruments



The RFA 4000 electronics and telecommunications plier kit includes five stainless steel pliers. The assortment from **RF Industries** will handle a variety of jobs, including trimming leads on circuit board components; attaching wiring harness cable ties; trimming coaxial cable; and making electronic adjustments.

Circle (357) on Fast Fact Card

### Mobile data starter kits work with many radio models

**Dataradio** starter kits allow mobile radio users, SMR system operators, system integrators and software developers to gain experience with mobile data at a minimum expense and with the flexibility of using a wide range of radios. The kit comes with step-by-step instructions to set up a simple mobile radio network. The VIS24 starter kit works with the E. F. Johnson 8605 and 8600 radio series, as well as with any con-

ventional two-way radio system, with or without repeaters. The VIS24 kit includes one 24F3MRM mobile radio modem, one BDLC-1 single port base station datalink controller, DRSETUP configuration software, an MTA modem test adapter for modem and radio alignment, radio interface cables and a documentation package. The VIS system also provides for an "open architecture" system design.

Circle (358) on Fast Fact Card

### Phone patch offers DSP voice recognition

The RTU-250 uses an adaptive hybrid to convert the four-wire audio from the transmitter and receiver to two-wire audio for the phone line. It automatically matches any phone line at all voice frequencies simultaneously to provide a broadband null with no oscillation in full duplex systems. Set-up is simple with the phone patch from **JPS Communications**; neither the VOX nor the adaptive hybrid require any adjustments.



Circle (359) on Fast Fact Card

## Get Control.



### Remote Control, of up to 16 Channels. Radius M200 or Maxtrac 300 Series Radios.

The CPI model MCR10 remote and MCR10P interface panel will allow you to remote control Radius or Maxtrac radios, up to sixteen channels, over any two wire voice grade circuit.

The MCR10 remote control system provides LED displays for remote channel indication, channel up and down buttons, PTT indicator, on-hook PTT capability, monitor button and indicator, intercom capability between parallel remotes and the radio, scan control button and indicator for those radios so equipped and speaker volume control.

#### Features

- Simple installation - No soldering, cutting or crimping.
- Provides remote channel indication.
- Does not require B308 option.
- Remote transmissions heard over radio speaker.
- Radio transmissions monitored on remote speaker.
- Uses any two wire voice grade circuit.



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Circle (74) on Fast Fact Card



## New products

### Radiotelephone controller provides service for 1,000 users

The RTX 6000 microprocessor-driven programmable controller allows mobile radios to be linked to local telephone exchanges so mobile radio operators can make local, national and international telephone calls using standard two-way radio equipment. The radio-telephone system by RTX offers mobile-to-telephone, telephone-to-mobile and mobile-to-mobile operation for individual and group calling



and service for as many as 1,000 mobile telephone users and 1,000 pagers. Brackets, hardware and instructions are included for installation, alignments and adjustments.

Circle (360) on Fast Fact Card

### CTCSS tone panel customizes repeater use



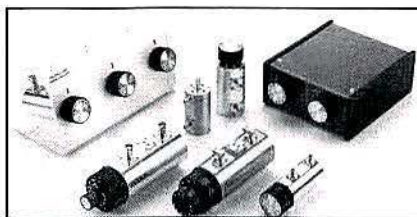
The TP-154 shared repeater tone panel serves 154 subscribers with 50 CTCSS

tones and 104 DCS codes. Programmable and per-subscriber features allow customizing the repeater on a per-user basis. The unit by Connect Systems can be locally or remotely programmed using DTMF signaling.

Circle (361) on Fast Fact Card

### Rotary attenuators range from dc to 4GHz

Rotary attenuators from JFW Industries are available in single, dual or bench mount units depending on the application. Standard frequencies range from dc to 4GHz. 50Ω and 75Ω units are available with BNC, TNC, SMA or N type connectors. Step size increments range from 0.1dB steps to 10dB steps.



Circle (362) on Fast Fact Card

### Battery line power ranges from 80mAh to 380mAh

The HydriCell NH series of batteries are standard charged for 14 to 16 hours and quick-charged in less than one hour under controlled conditions. The Plainview Batteries have maximum continuous discharge current of 80mA to 380mA. The maximum pulse discharge current is 0.7A to 2A in two seconds.



Circle (363) on Fast Fact Card

### Adjustable phone mount holds almost anything

The SD1 6000DC phone mount can adjust to hold items, such as portable radios, cellular telephones, flashlights, police batons and coffee mugs, from 1 1/8" - 3 1/4" wide, 5 1/2" - 8" long, and 1" - 3" deep. The versatile mount from Scientific Dimensions can adapt to any AMPS compatible pedestal mount and can be incorporated into a mobile office configuration.



Circle (364) on Fast Fact Card

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Circle (75) on Fast Fact Card

### Dual-amplifier remote control covers 1,000 foot distance



Model 805AY amplified local remote control provides 1W speaker audio and 2.6Vrms TX mic audio at 600Ω with separate Tx and Rx amplifiers. F1 and F2 select and monitor switches are standard on the Solid-State Communications unit. Multiple 805AYs may be "daisy chained" to a single base station and normally can be used up to 1,000 feet.

Circle (365) on Fast Fact Card



## Crimp tool kit crimps pins, ferrules on low loss cables

The RFA-4005 crimp tool kit includes the crimp tool frame and two interchangeable dies. It crimps the pins and ferrules on the majority of any crimp connectors made for RG 58/U, RG 59/U, RG 8X,

Proflex, RG 8/U, RG 213, RG 214 and Belden 9913 and 9914 low loss cables. The kit crimps **RF Industries'** and competing companies' connectors. Optional die sets are also available.

Circle (369) on Fast Fact Card

## SMR voice mail system offers individual subscriber programming

The **Hark** Voice Mail System mailbox can take messages, play the greeting only, forward to another mailbox and forward to an extension or outside number. The system allows SMR operators to program individual subscriber services in the back-

ground including initiating and interrupting service to individual mailboxes. Easy extension maintenance allows providers to program each mailbox for various levels of service.

Circle (370) on Fast Fact Card

## Vehicle location system provides real-time position

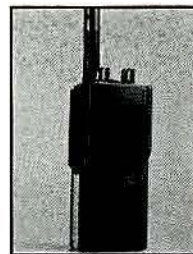
NavTrax vehicle location and management system provides real-time position, speed and heading information of vehicles. Information from the vehicle is transmitted via two-way radio, mobile telephone or orbital satellite to an operations center. The data are superimposed on high resolu-

tion maps displayed on a computer screen. NavTrax can be integrated with the user's existing communications or CAD systems. The system can achieve accuracy from less than 16 feet to 330 feet. **Pulsearch**, in association with Armata Technologies, has been working on this system.

Circle (371) on Fast Fact Card

## Radio receives intrinsically safe listing

The **Maxon** SP-5050HD is a 5W, 6-channel VHF low-band radio operating in the 25MHz-to-50MHz range. The radio has received the intrinsically safe listing and is listed for



Class 1, Division 1, Groups A, B, C and D.

Circle (372) on Fast Fact Card

## Decoder uses low power CMOS

The TD-1 programmable DTMF decoder supports selective, group and all call with timed automatic, hookswitch and DTMF selective call resets. An auxiliary forced decode input is also provided. User programmable features include 9-digit DTMF call codes, auto-reset time, interdigit time and hookswitch input polarity. The TD-1 from **NCC** uses a low power CMOS microprocessor design and is programmed with a standard DTMF telephone.

Circle (373) on Fast Fact Card

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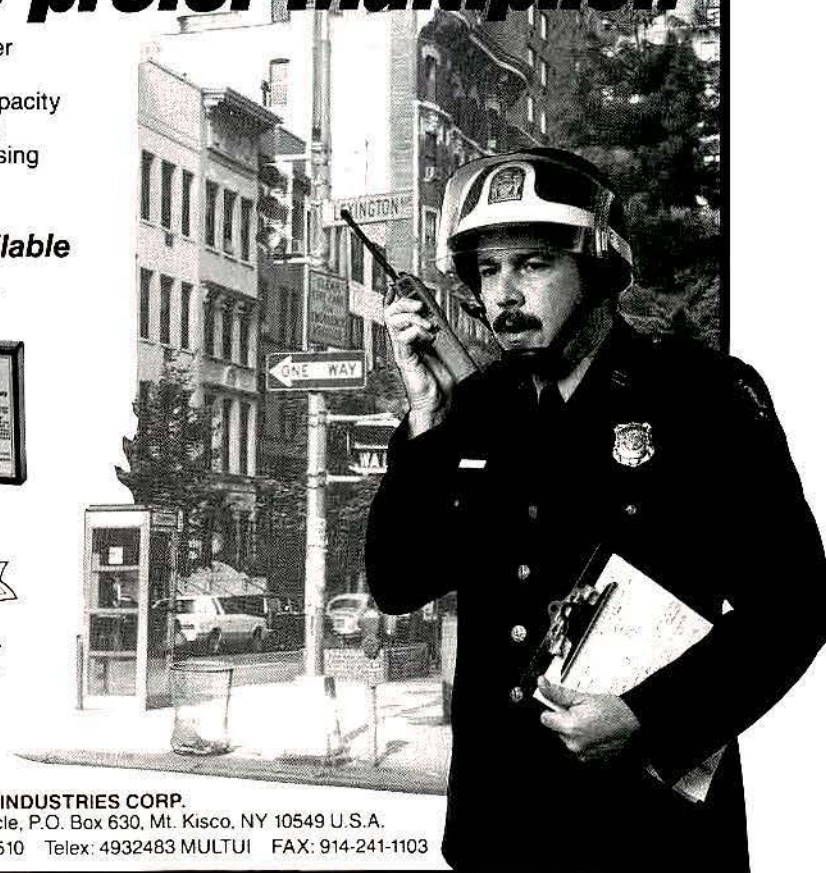
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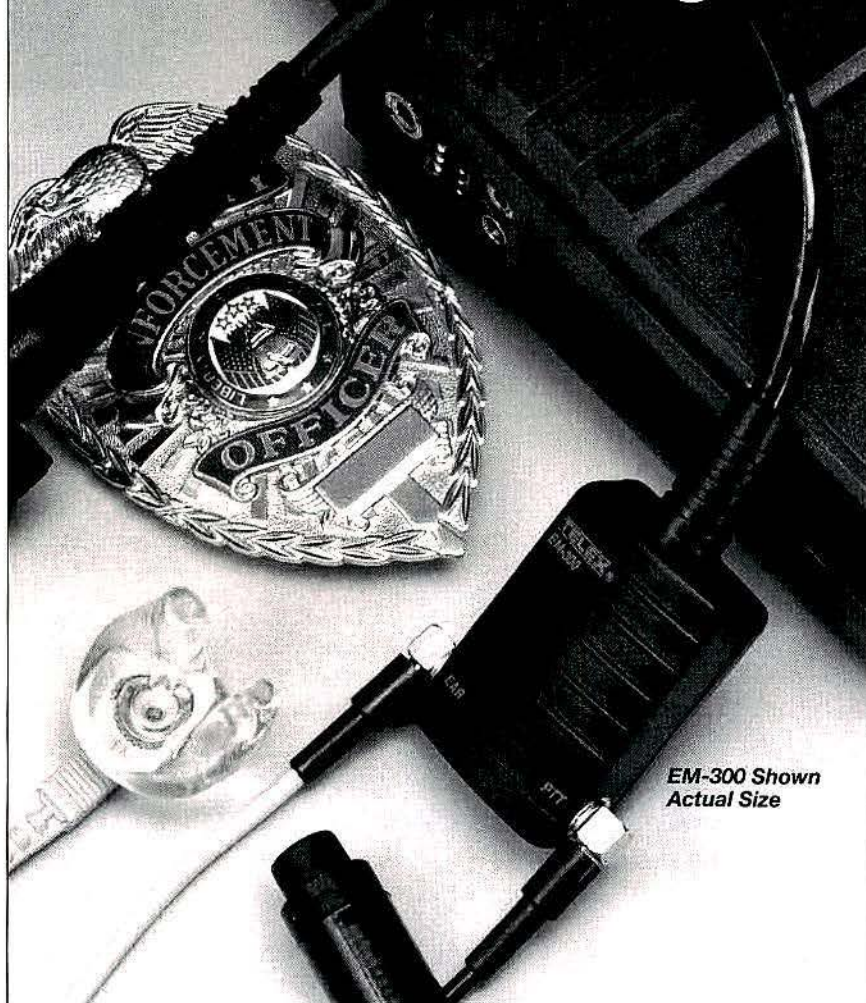
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Circle (69) on Fast Fact Card



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**TELEX**

Circle (70) on Fast Fact Card

## New products

### Hand-held transceiver boasts 4-channel selector switch

The Procom-MU54 is a 5W, 4-channel UHF FM transceiver that operates on General Mobile Radio Service, either simplex or repeater mode; and Business Radio Service, simplex mode. The radio from **Fanon Courier** features a four-channel selector switch; a hi-lo power switch; adjustable squelch control with tone squelch on-off switch; external antenna; and remote speaker and microphone.

Circle (366) on Fast Fact Card



### Cellular data monitor analyzes, troubleshoots signals

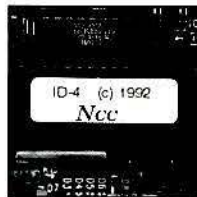
As a versatile analysis and fault-finding tool, the CDM-100 converts digital cellular control signals to standard RS-232 format. It decodes all control messages, forward and reverse, on both the voice and control channels. The unit from **Communications Test Instruments** can be used with various FM communications receivers, service monitors or cellular phones.

Circle (367) on Fast Fact Card

### Identification module adds DTMF decoder

The ID-4 is a user-programmable CW identification module with multiple trigger and busy inputs. Programming features include ID speed and frequency, busy level, external trigger level, two 18-character messages and DTMF selective call IDs. The unit by **NCC** uses a polite ID protocol and programmable interval timer for automatic IDs and can be programmed to send an ID after the transmitter has been externally keyed. The ID-4 programs with a standard DTMF telephone and can be installed quickly into any radio system.

Circle (368) on Fast Fact Card





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## Brochure depicts directional RF power meters

A color brochure offers details about **Bird Electronic's** laboratory grade directional RF power meters, models 4420 and 4421. The precision measuring instruments offer accuracy, wide power and frequency input ranges—100mW to 10kW and 1.5MHz to 1GHz—and modular configuration for flexibility and expansion.

The brochure introduces the company's smart power sensors, the companions to 4420 and 4421 meters. The six-page brochure includes a description of model 4029 power sensor calibrator. With a CRT terminal or PC with a serial port, the 4029 calibrates RF power sensors.

Circle (300) on Fast Fact Card

## Handbook features radio electronics

The 70th edition of **ARRL's** handbook for radio amateurs features projects and updated theory explanations. Included in the 39 chapters are electrical fundamentals, radio principles, modulation methods, construction techniques and test equipment. The 1993 handbook has additions such

as a 4.5V-to-23V, 2.5A precision power supply; a discussion of feedback-loop design; a discussion of simple wire antennas and baluns; an on-glass VHF and UHF antenna project; and an updated list of parts and suppliers.

Circle (302) on Fast Fact Card

## Catalog lists cellular mobile antennas

A 16-page catalog provides descriptions and technical specifications for more than 70 cellular mobile antennas and accessories. **Antenna Specialists'** line of On-Glass, elevated-feed, roof-mount, temporary mount, portable and marine cellular antennas are presented, as well as special purpose mounts.

Circle (303) on Fast Fact Card

## Technical specs describe remote radio

Literature and technical specifications from **Alligator Communications** describe the MPR1888 remote radio for multiple address radio systems (928MHz to 952MHz). Included are descriptions of the remote control capability and diagnostic data acquisition for remote diagnostics, and storage for trend studies.

Circle (304) on Fast Fact Card

## Study examines communications needs

"Wireless Local Services: Opportunities, Competition and Strategies" looks at the needs of residential and business telephone users. The information came from a nationwide survey of 1,092 households and 747 businesses analyzed by 45 demographic, industrial, product and user segments. The survey, conducted by **Alexander Resources**, found that plans for Personal Communications Services (PCS) ignore many high-demand communications services that could be provided by wireless technologies.

Circle (301) on Fast Fact Card

## Video manual shows thru-hole desoldering

The SX-70 Sodr-X-Tractor video manual covers all aspects of set-up, operation and maintenance of the Sodr-X-Tractor for self-paced training of new and existing production line employees. The video tape from **Pace** is easy to follow and explains handpiece set-up, tip selection, setting tip temperature, tip and board preparation, cleaning and maintenance. A special emphasis is placed on desoldering heavy multilayer boards, unclenching leads and desoldering terminal wires.

Circle (305) on Fast Fact Card



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Circle (72) on Fast Fact Card



## 'Know how to use test equipment'

Test equipment and methods vary among the respondents to the June 1992 "What Do You Think?" questionnaire. 73.3% of the readers have purchased test equipment in the last 12 months.

Test equipment currently used by the respondents include: (multiple responses add up to more than 100%)

Wattmeters	94.2%
Multimeters	93.0%
Oscilloscopes	90.7%
Service monitors	89.5%
Voltmeters	88.4%
Frequency counters	84.9%
Tone generators	83.7%
Power meters	82.6%
RF signal generators	82.6%
Spectrum analyzers	76.7%
Sweep generators	51.2%
Other	37.2%

Helpful test methods include:

- "Automated tests speed results return. Also, printed reports can be created to compare and save results."
- "Built-in SINAD measurements and multifunctions of a communications analysis."
- "Circuit isolation and evaluation of performance."
- "Divide and conquer."
- "Flow chart voltages and waveforms on diagrams."
- "Interrogating the customer to nail the exact radio problem down (saves a little bench time, anyway)."
- "Know how to use test equipment. Know circuits and how they work."
- "Observation."
- "Signal generation."
- "Signal injection."
- "Signal substitution."
- "Signal tracing."

Improvements readers would like to see in test equipment include:

- "Affordability."
- "Basic frequency accuracy, better printed diagnostic data and more accurate diagrams."
- "Better resolution."
- "Better selection of low cost equipment."
- "Less bulky."
- "Less susceptible to outside RF and microprocessor noise generated in equipment."
- "Make it smaller and lighter."
- "More computer interface."
- "More explanatory "help" screens."
- "More options built-in."
- "Portability, battery life weight decrease, software for special tests."



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Circle (78) on Fast Fact Card

## P eople

Changes at RF Industries (RFI), San Diego:

**Les Perlman**, marketing manager, moves up to distributor sales manager for domestic and international operations. **Joe LaFay**, the head of OEM sales, advances to OEM and rep sales manager.

Neulink manager **Woody O'Keefe** advances to Neulink Division general manager.

Cad manager **Connie Jones** moves up to graphics and connector design engineer manager. **Perry Breaux** exits G.W. Surfaces, Escondido, CA, and joins RFI as a graphic designer. **Karla Maxwell** discontinues self-employment in Vista, CA, and becomes a graphic designer at RFI. **Darlene Morris** departs Anvil Designs, Vista, CA, and joins RFI as a graphic designer.

**J.F. Blanchard** exits Blanchard Associates, La Costa, CA, and joins RFI as an administrative consultant. **Lisa Garcia** departs General Dynamics, San Diego, as a senior buyer to become RFI's purchasing manager.

Senior technician **Tony Huber** advances to production-technical supervisor, Neulink Division.

Electronics assembler **Renato Aquino** advances to senior technician.

**Donna Pitts** exits Linvatec, Largo, FL, as a territory manager, to become managing director of federal services and Mid-Atlantic region for Lincoln, NE-based Transcript International in its Washington, DC, office.

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Changes at Microwave Filter, East Syracuse, NY:

**Carl F. Fahrenkrug**, executive vice president and chief operating officer, takes over as president, succeeding **Glyn Bostick**, who founded the company 25 years ago.

**Robert Portmess**, vice president of manufacturing, moves up to executive vice president, and company treasurer **Richard Jones** advances from vice president of accounting to vice president and chief financial officer, and continues as treasurer.

**David Headley** leaves Comband Technologies, Chesapeake, VA, as national sales manager to join Microwave Filter as national sales manager.

**Frederick J. Day, Esq.** leaves Keller and Heckman, Washington, DC, as a communications attorney to become the Industrial Telecommunications Association's (ITA) director of government relations.

**Kevan Bloomgren** departs Daniels & Associates, Denver, as vice president to join Satellite Paging, Fairfield, NJ, as vice president and chief financial officer.

**Gary Smith**, senior vice president, Glenayre Electronics, Charlotte, NC, moves up to research and development group vice president.



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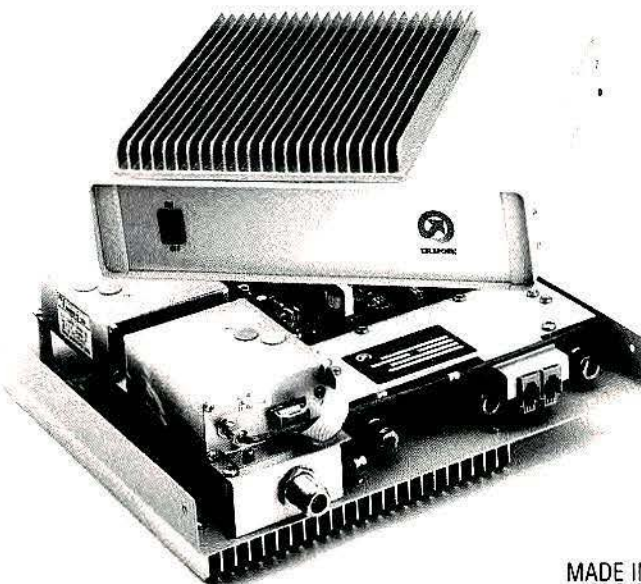
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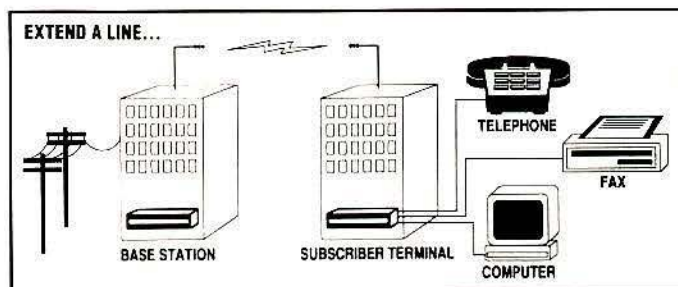


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# Mobile Radio Technology

The journal of mobile communications technology

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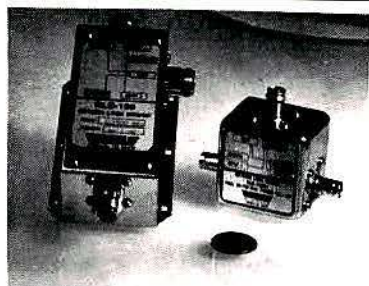
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### Uses:

- Tuning Antennas: Base, mobile, or glass
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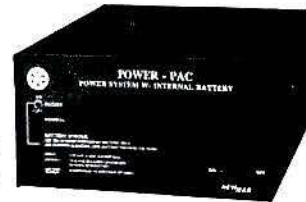
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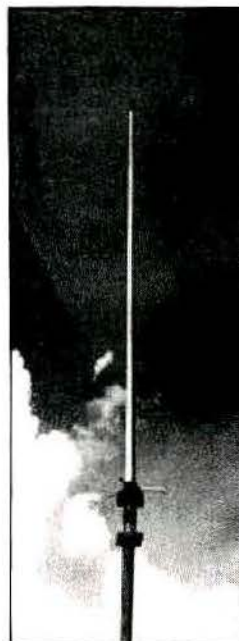
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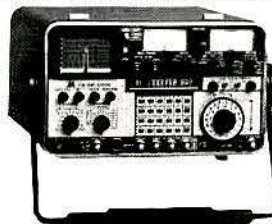
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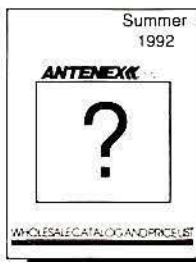
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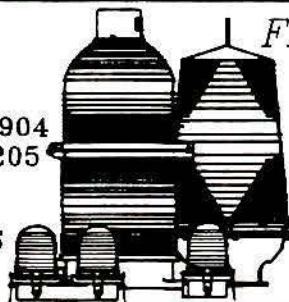
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## ad index/hot line

Company	Page Number	Fast Fact Number	Advertiser Hot line	Company	Page Number	Fast Fact Number	Advertiser Hot line
Air Comm	86	124	602-275-4505	Meridian Comms/Diablo Comms	48M,63	63,95	818-888-7000
America West C&E Inc.	92	140	800-542-WEST	Meridian Comms-Comms Express	85	118	800-631-7297
The Antenna Specialists, Co.	IFC	1	216-349-8400	Micro-Quick Systems, Inc.	94-95	146	800-874-7749
Astron Corp.	48I,61	61,90	714-458-7277	Microwave Filter Company Inc.	56	56	315-437-3953
Automation & Electronics Engr.	84	114	800-527-4596	Midian Electronics, Inc.	41	38	602-884-7981
Avcom of Virginia	56	55	804-794-2500	Mobile Mark, Inc.	30	27	800-648-2800
B&C Communications Inc.	81	129	800-343-3004	Modular Communication System	18	16	818-764-1333
Bomar	14	12	800-526-3935	R.P. Moses & Co., Inc.	82	113	516-679-8774
California Radio	83	111	800-231-0103	Motorola Government	15	13	800-235-9590
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Celwave	19	17	800-321-4700	MX-COM, Inc.	7,48K	7,92	919-744-5050
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C.E.T., Inc.	93	144	800-445-0297	Norton Engineering	93	143	703-938-5745
Chargeguard Corp.	87	125	800-458-3410	Omnicon Electronics	77	80	203-928-0377
Cimaron Technologies	23	20	800-487-7184	Orbacom Systems, Inc.	27	24	609-829-4455
Coded Communications	11,48G	9,88	800-228-6367	Pekaar Communication, Inc.	88	130	201-772-0704
Communication Instruments	89	134	800-288-8223	Phillips Business Infor. Inc.	88	131	800-777-5006
Communication Plus	83	110	800-561-3140	Pirot, Inc.	65	66	219-936-4221
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Control Signal Corp.	16	14	303-989-8000	Radio Express, Inc.	82	112	703-266-1928
CPI Communications, Inc.	48N,69	74,96	800-869-9128	Ramsey Electronics	85	121	716-924-4560
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Data Signal, Inc.	26	23	912-883-4703	Santa Fe Distributing	52	50	913-492-8288
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Decibel Products, Inc.	37	34	214-631-0310	Selectone Corporation	3,48P	5,99	800-227-0376
Diablo Communications, Inc.	91	136	510-236-3700	Sentry Services Int'l	92	139	407-773-6090
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Hutton Communications	34,50	30,48	800-442-3811	Trident Micro Systems	43	40	800-798-7881
Hy-Q International	83	109	606-283-5000	TWR Lighting Inc.	91	137	713-973-6904
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Larsen Electronics	59	59	206-944-7551	Vocom/RF Corporation	64	65	800-USA-MADE
Leathersmith	70	75	800-233-0440	Wacom Products Inc.	64	64	817-848-4435
Maxrad, Inc.	39	36	800-323-9122	WorldWide Electronics	76	79	818-718-7920
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